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FLIES WHICH CAUSE MYIASIS IN MAN AND ANIMALS—SOME ASPECTS OF THE PROBLEM

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SOME FORMS OF MYIASIS AND SPECIES OF FLIES CONCERNED

For many years medical literature has contained reports on cases of myiasis of different kinds in man. It is impossible to say how long man and animals have been subject to the attack of fly larvæ. It is safe to conclude that the meat breeding habits of certain Sarcophagidæ and Muscidæ have existed for many centuries, and although the habit of attacking living animals may have been developed later, there is in many cases no material difference between the infesting of dead and decaying tissue in a living animal and the infestation of carcasses. From this point it is but a short step to the development of the habit of feeding on healthy as well as dead and diseased tissue, and ultimately we find the forms which freely attack uninjured tissue requiring nothing but an external drop of blood to attract the fly and induce deposition. In the Œstridæ, or bot fly family, we find a more intimate and complete relationship to or dependency upon the host. The form of myiasis produced by this group of flies is quite different, of course, from that exhibited by the Sarcophagids and Muscids.[2] The flies are more specialized in habit and structure for parasitic life. This degree of

[1] Published by permission of the Chief of the Bureau of Entomology.

[2] Cordylobia, an African genus which has been considered to be a Calliphorine, has a habit somewhat similar to the bots. The larvæ of this group cause dermal myiasis in man and lower animals. In Africa we also find the Calliphorine flies of the genera Auchmeromyia and Chaeromyia, the larvæ of which have the peculiar habit of sucking blood from man and the lower animals.

specialization varies to some extent with the species. We see, for instance, an example of the most complete form of parasitism in the ox warbles of the genus Hypoderma; here the parasite has become highly dependent on the host, and confines attack largely to one host, the ox. The habit of the larvæ of migrating to the back of the host, where development is completed, and the fact that the larvæ seldom live if removed from the host a short time even before their normal emergence, probably indicates a closer relationship to the host than in the case of the horse bots or other members of the family. Although this is an exceedingly interesting group of flies it is not my purpose to dwell at length upon it, except to call attention to the occurrence of some of the varied forms of myiasis produced.

The sheep bot (*Œstris ovis*) is primarily a pest of sheep yet we find that it attacks other animals and even man. Ed. and Et. Sargent[1] state that this fly attacks man in certain elevated regions in the Sahara where sheep are less numerous than people. The eggs or larvæ are deposited upon the conjunctival and nasal mucous membranes of man and cause much trouble from March to June. In this country no records have been made of myiasis in man produced by this species. It is fairly common in many parts of the United States, and the habit of the larvæ of passing up the nostrils and into the sinuses of sheep is well known. It is not usual for it to invade the tissues of the host but appears to subsist on the mucous secretions.

The ox warble (*Hypoderma lineata*) is our most important species in the United States. Its near relative, *H. bovis*, has recently been found by Drs. Hadwen and Hewitt to have a wide range in Canada, and it is now probably within our northern border. Certain points in the biology of our species have not been definitely determined, and these are giving rise to considerable discussion. The entomologists in this country are inclined to the view that the larvæ gain access to the back of the bovine host by way of the œsophagus, while some European authorities believe the larvæ penetrate the skin along the back or migrate beneath the skin from the legs to the back. It is not my purpose to discuss the merits of the case. If it is true that the larvæ migrate from the œsophagus to the back, we have a case of a combined internal, transient myiasis followed by dermal myiasis. Cases of man being infested by larvæ of this genus are not rare. In some instances the larvæ move about beneath the skin until mature, while in other cases they have been recorded as developing at the root of the tongue or within the orb of the eye.

[1] 1913. Sargent, Ed. and Et. La "Tamné," myiase humaine des montagnes saharennes tonareg, identique à la "Thimni" des Kabyles, due à *Œstris ovis*. Bull. Soc. Path. Exot., Paris, VI, pp. 487–488.

In this same family we have three or more species of horse bots with more or less different habits, but all attaching to the stomach or intestines of the host. These probably derive their food largely from the secretions of the mucous membranes and from the contents of the digestive tract. The exact relationship to the host is not known and it is important that the extent of injury to the host be carefully determined, as is being done in the case of Hypoderma by the German commission which has been studying that problem.

Among the Œstridæ we also find the species *Dermatobia hominis*, which is a common cause of dermal myiasis in man and a number of the lower animals in tropical America, and the members of the genera Cuterebra, Œdemagena, Gedœlstia and Cephenomyia. None of these latter forms have been known to attack man.

Comparatively little is known regarding the exact rôle flies play in myiasis of the intestinal and urinal tracts. Numerous records have been published showing from one to several species in the following families to be concerned: Therevidæ, Syrphidæ, Muscidæ, Anthomyidæ and Sepsidæ. In many instances rather serious disturbances in man are due to the larvæ of these flies. No doubt many infestations pass unnoticed or produce only minor symptoms, the larvæ depending on the food of the host for sustenance, and thus producing no direct injury. The mode of infestation and the effects of the larvæ on the host deserve much more attention than has been accorded them.

I desire at this time, to deal particularly with the various species of flies, the larvæ of which infest man or animals in wounds or, as not infrequently happens, attack inflamed or even entirely healthy parts. The species concerned are members of the families Muscidæ and Sarcophagidæ, as recognized by most of our American dipterists. In the United States the forms which are most important in causing this form of myiasis are *Chrysomyia macellaria*, *Lucilia sericata*, *L. cæsar*, *Phormia regina*, and one or two species of Sarcophaga. Possibly species of the genus Calliphora and Cynomyia are sometimes concerned. *C. macellaria* far outranks all others combined in importance. This species occurs in Mexico, the West Indies, Central America, and South America. In South America, Neiva and Gomes de Faria[1] have shown that *Sarcophaga pyophila* is responsible for some cases, at least, of human myiasis. These authors[2] also state that *S. lambens* is known to cause human myiasis in Brazil. In Hawaii, Van Dine

[1] 1913. Neiva, A. and Gomes de Faria. Notal sobre um caso de miiase humana ocasionada por larvas de *Sarcophaga pyophila* n. sp. Memorias do Oswaldo Cruz, Tomo V, Fasc. 1, pp. 16–22.

[2] *Ibid.* p. 18.

and Nörgaard[1] state that *Calliphora dux* Esch. during some seasons causes heavy losses among sheep by attacking scars caused by sheep scab and by blowing soiled wool, from which the larvæ ultimately work into the flesh. In Australia the losses to sheep raisers due to related species of flies have been enormous. Professor Froggatt has studied the various forms concerned and has published a number of papers dealing with the pests. The most important of these was published in 1913.[2] As a result of his investigations Professor Froggatt found that three species of blow flies indigenous to Australia are responsible for the infestation of sheep. These are *Calliphora oceaniæ*, *C. villosa*, *C. rufifacies*. Although the common green-bottle flies, *Lucilia sericata* and *L. cæsar*, occur commonly in Australia, these species have not been bred from soiled wool in that country. In Great Britian, and parts of continental Europe, these species, especially *L. sericata*, are commonly known as the sheep maggot flies, being responsible for the blowing of wool there. In southern Russia it appears that the fly, *Wohlfahrtia magnifica*, is the principal culprit in connection with this type of injury to sheep. Portchinsky[3] states that this species, which is viviparous, is very annoying and dangerous to sheep. Twenty-five per cent or more of the sheep are infested annually by its larvæ. *Sarcophaga ruficornis* is one of the flies which produces severe forms of myiasis in India.

Importance of Muscids and Sarcophagids which cause Myiasis in Man and Animals in the United States

Relationship to Slaughterhouse and Other Food Products.—As has been stated, a number of species of flies are concerned in the production of myiasis in man and animals. Of these, *Chrysomyia macellaria* is by far the most important. Aside from the causation of myiasis, the flies of this group are of considerable importance. They all have the habit of visiting carcasses and other decaying animal and vegetable matter, and are likewise rather strongly attracted to blood and fresh meat, as well as cooked meat and other good products. In parts of the south, in particular, these flies are a veritable pest about slaugh-

[1] 1908. Van Dine, D. L. and Nörgaard, V. A. Abstract of a preliminary report on insects affecting live stock in Hawaii. Proc. Hawaiian Live Stock Breeders' Association, Fifth Annual Meeting, 1907, pp. 19–70.

[2] 1913. Froggatt, W. W. and Cooper, W. F. The sheep maggot fly pest in Australia, pp. 88, figs. 15. The Cooper laboratory for economic research, Watford, England.

[3] 1913. Portchinsky, A. [Memoirs of the Bureau of Entomology of the Scientific Committee of the Central Board of Land Administration and Agriculture.] Vol. 9, No. 5, pp. 30, figs. 23. St. Petersburg.

terhouses. The small country plants which are not under the supervision of the government inspection service are especially prone to this condition. In most of these slaughterhouses the offal is left in the yard immediately adjoining the killing pens or is fed to hogs. Usually the hogs are not numerous enough to consume all of the offal, so that in either case a great number of these meat-infesting species are bred out. Under favorable seasonal conditions swarms of thousands of flies are present about the building, and as soon as an animal is skinned they begin feasting on the blood and the fresh carcass. If extreme vigilance is not exercised, the carcass is often blown in a short time after killing, and in some cases the eggs hatch and the larvæ begin to penetrate the meat. The meat-breeding flies are not the only species which visit food products in slaughterhouses. The house-fly is often present in great numbers and may contaminate meats with its feet and excrement, although it does not deposit eggs in such situations.

Knowing the filthy habits of the flies, we cannot help but look upon them as dangerous when allowed free access to food products. It has been shown by several investigators that various bacteria may pass through the alimentary tract of flies without destruction. Of course, where meat is well cooked probably these germs are all killed. On the other hand such food products as cooked meats, sausages, etc., which are usually consumed without further cooking, may be contaminated with all sorts of germs as well as fecal matter and other filth. Certainly, where flies have free access to carcasses, as is commonly permitted in many places, the bacteria of decay are introduced and the meat has its keeping qualities impaired. As has been pointed out recently in an Australian journal,[1] several advantages accrue from careful protection of meat from flies. In this instance the largest firm of butchers in Auckland began using screens for the protection of their meat. This resulted in a saving due to the prevention of trimming necessary when the meat is blown, improved the keeping quality of the meat, increased sales, and lessened the quantity of ice needed. In fact, they found the practice so advantageous they extended the screening system to all of their branches.

Although our butchershops in the towns and cities by no means furnish the best conditions as regards flies, they are incomparably better than the conditions often encountered at the small abattoirs. A careful inspection of such plants and the enforcement of sanitary regulations should be a part of the duty of every health officer.

Injury and Losses Due to Myiasis.—The flies of this group appear to be of little importance as causes of intestinal myiasis. A few cases

[1] 1913. The protection of meat from flies. Australian Medical Gazette, Sydney, Vol. XXXIII, No. 18, May 3.

have been observed where live stock have become infested with the screw worm (*C. macellaria*) in the stomach. These infestations were probably derived from licking wounds where eggs of the fly had been deposited, thus conveying the ova or young larvæ into the stomach where they penetrate the tissues. Considering the frequency with which animals lick infested wounds, it is remarkable that more evidence of internal attack is not at hand.

The habit of flies of attacking man is well known in the United States. Numerous cases have been reported by physicians and entomologists. Nearly all of these have been accredited to *C. macellaria*, although other species are no doubt responsible for part of them. In the southwestern states our investigations show that the infestation of man by fly larvæ is common. Cases of nasal or auricular myiasis have been well described in literature, so that further details are unnecessary. We have found, however, that the occurrence of larvæ in various parts of the body of man is not at all uncommon. The infested lesions on the surface of the body are much more easily freed from maggots than when these occur in the nasal or auricular regions, hence these cases have received little attention. Although infestations in cavities of the head formerly led to death or serious disfigurement, a better understanding of the pest has permitted physicians to treat such cases more successfully in recent years. Even now, however, death occasionally results from this cause.

Among live stock, myiasis is of most importance on the large ranches in west Texas, New Mexico, and Arizona. As has been stated, this loss is largely chargeable to the screw worm, *C. macellaria*. During early spring, however, there is considerable trouble among sheep on the ranches in west Texas, apparently due to the two species of Lucilia. This injury is of a different type from that caused by the screw worm. The soiled wool of ewes is infested at lambing time and, if not destroyed, the larvæ ultimately penetrate into the flesh and cause the death of the host. In treating cases it is often necessary to sheer a large portion of the sheep. The destruction of wool, together with the time occupied in treatment, to say nothing of the actual death of sheep, is a source of much loss among sheep-raisers.

During the winter months, especially when mild days occur following dehorning, castration and branding, infestation of resulting wounds by larvæ of *Phormia regina* is not uncommon. The infestation of heads of animals following dehorning is the most serious, and when not promptly treated frequently results in the death of the host. Possibly other species than *P. regina* are concerned in these winter infestations.

Our investigations indicate that nearly all of the cases of myiasis in animals during the summer and fall months are due to *C. macellaria*.

The damage chargeable to this species is of many classes. In certain sections of the southwest stockmen have found it unprofitable to keep breeding cattle on account of the heavy loss due to this pest at calving time. In these sections the stockmen depend mainly for replenishment of their herds upon purchase of yearlings. In nearly all of the cattle country of the southwest, the screw worm has had the effect of causing stockmen to reduce the size of their herds, especially during the fly season, in order that they may watch more closely the animals and promptly care for infestations. Under these conditions the actual death loss is not great although throughout the entire region the number of cattle actually killed by the screw worm must number well into the hundreds. Where animals become heavily infested with screw worms they have a tendency to penetrate thickets and are thus not found by the stockmen, and death usually results very shortly due to the extensive destruction of tissue by the larvæ or septicemia as a result of their presence.

Another important source of loss is the expense incurred by watching the herds and treating infested animals. Most of the pastures in the southwestern country are of great extent, many of them containing several thousand acres, and the promptness of treatment demanded necessitates the employment of a number of men to continually ride the pastures and treat the infested animals. The summer of 1913 was a year of especially great screw worm abundance and a large percentage of the stockmen found it necessary to employ extra help in order to prevent heavy death losses from infestations. During this season the percentage of infested animals in a herd ranged from ten to one hundred. In a number of instances from three to ten men were kept continuously busy on this line of work from May to November. To this we must add the expense of materials used in treating the infested animals. Chloroform is the most generally used, and I am informed by dealers that their sales of this material alone often reach five hundred dollars during one season. Individual owners of cattle sometimes spend several hundred dollars for chloroform, creosote products, pine tar, and other screw worm remedies.

Source of Infestation.—The screw worm, *C. macellaria*, has developed a very marked tendency to attack living animals although it breeds in great numbers in carcasses. This frequently gives rise to infestation of an animal on the least provocation. Years when the flies are very numerous, practically every scratch becomes a site for screw worm entrance. These may be made by brush, barbed wire, or the horns of other animals. On account of the frequency with which wounds are attacked the stockmen usually do not mark or brand live stock after May first or before November first. In this way they avoid much trouble.

Even when branding is done during late spring or early fall the maggots frequently infest the injured area. Dehorning and castration are almost invariably done during the winter months to avoid screw worm attack. Any animal giving birth to young during summer months is likely to become infested and the offspring is frequently attacked at the navel. Calves often get blown in their mouths, causing the loss of their teeth. Practically all animals are attacked but cattle are probably most susceptible. Infestation in hogs is usually seen in their ears as a result of wounds due to fighting. In the case of sheep, goats and dogs, infestation may occur on any portion of the body where injury is sustained. This species does not deposit on soiled wool but is strongly attracted to blood.

Another frequent source of infestation results from the presence of the cattle tick or other species, and live stock attacked by large numbers of horn flies, stable flies or Tabanids invariably develop cases of screw worms. Heavy infestations of ticks produce skin lesions, and when screw worm flies are numerous they frequently blow spots where a tick has been crushed, the larvæ penetrating through the skin. The large number of cases of screw worm infestations developing from the presence of ticks has caused an increased desire on the part of stockmen in many sections to eradicate the tick, and by this means lessen the injury by the screw worm.

Relationship of Meat Infesting Flies to Disease Transmission.—This question has been briefly touched upon under the discussion of slaughterhouse conditions. It is a question which has received little attention but is deserving of more extended investigation. It seems certain that there is some connection between the carcass-infesting flies and the so-called limberneck in chickens. Chickens have been observed to become partially paralyzed and frequently to die from the eating of maggots and decaying animal matter. We now have investigations under way to determine the relationship existing between the maggots and this disease. Dr. E. W. Saunders, of St. Louis, believes that there is some connection between limberneck in fowls and poliomyelitis in man, and that certain species of blow flies are responsible for the transmission of the disease. He has recently published[1] the results of some experiments along this line.

During the last two years rather severe outbreaks of anthrax have occurred among live stock in Texas. Observations on the habits of the meat-infesting flies, particularly *C. macellaria*, in connection with these outbreaks, certainly suggest the possibilty of the transmission of this disease by them. Carcasses of animals which have suc-

[1] 1913. Saunders, E. W. The prophylaxis of poliomyelitis, anterior acuta. Journal State Medical Association, IX, No. 12, pp. 385–389.

cumbed to the disease are soon covered with swarms of flies which feed upon the excreta, blood, etc., and then pass to wounds on other animals where infection may be produced by bacilli carried on the legs and body or by regurgitation of the germ-laden food or possibly by excrement. Thousands of flies develop in the carcasses where they are not properly disposed of and there is a strong probability of the resulting flies being capable of conveying the virulent organisms to healthy animals.

Summary of Life-History and Seasonal History of Some of the Species of Flies which Produce External Myiasis in the United States.

Mr. E. W. Laake, working under my general direction, at Dallas, Texas, is responsible for most of the notes on the life-histories from which the following summaries have been made. Work along similar lines was conducted by Mr. J. D. Mitchell at Victoria, Texas, and by Mr. D. C. Parman at Uvalde, Texas.

Chrysomyia macellaria.—The method of wintering of this species has not been definitely determined. In our hibernation experiments with adults and immature stages we have been unable to carry the species through the winter. This, and other points, indicates that the species normally dies out in the winter except possibly in the extreme southern portion of the United States, and in the tropics, and the reinfestation of the country progresses as the season advances. The species appears shortly after settled warm weather begins in the spring and the number usually increases until frosts in the fall. Often a partial checking of the ravages of the species occurs in midsummer, especially when the weather is hot and dry. The first infestations of live stock are found usually in May, and September and October are as a rule the months of greatest injury. In western Texas, where the rainfall is normally small, the years with abnormally heavy rainfall are generally the most productive of screw worm infestations.

The period from emergence of adult flies to deposition of eggs ranges, as observed by us, from three to eighteen days. As many as eight consecutive depositions by one fly have been observed to take place, the period between depositions being from one to seven days. Under the best conditions it seems that the depositions may occur at intervals of two to four days. The number of eggs deposited in one batch appears to vary from forty to two hundred forty-eight, and the greatest number recorded from one female was twelve hundred twenty-eight. The larvæ hatch within a few hours. Pupation occurs from six to

twenty days later and the pupal period ranges from three to twenty-seven days. The total developmental period from egg to adult has been found to vary from nine to thirty-nine days. None of these records were made on infestations in living animals. Breeding proceeds continuously throughout the summer, and no doubt from ten to fourteen broods are produced in one season in southern Texas. Considering the reproductive capacity of this species it is not surprising to note the millions of flies present about decaying animal matter in mid-summer. By rather careful estimation we judge that a single carcass may produce upwards of a million flies of this species.

We have observed a very marked tendency of this fly to breed in animals which have died recently rather than in old carcasses. This habit probably is related to that of the species depositing in living animals. Although some observers have found this species commonly deposits living young in the more northern latitudes, we have failed to observe this phenomenon in connection with our work. This species occurs normally in all sorts of situations in the Southwest, but we have observed a marked tendency for it to be found in great numbers far from any habitation. In such situations often no other species of meat-infesting flies is to be seen, while in cities the two species of Lucilia often outnumber the one under discussion.

Lucilia sericata.—Our experiments indicate that this species normally passes the winter in the larval and pupal stages. It is usually seen flying about or breeding early in the spring before *Chrysomyia macellaria* has appeared. Breeding takes place in decaying animal matter, although the adult flies are often seen frequenting all sorts of places in search of food. The first oviposition occurs, in summer time, within five to nine days after the adults emerge from the puparia. The incubation period varies greatly with the temperature. In summer, hatching takes place in less than twenty-four hours while in autumn we have a record of seven days. Pupæ are formed in three to nine days after hatching, and adults emerge within three to thirteen days after pupation. The developmental period, from egg to the emergence of the adult, ranges from nine to twenty-one days. These records were made during comparatively warm weather.

Lucilia cæsar.—This species, like the one just discussed, winters in the larval and pupal stages, the adults appearing on the first warm days of spring or even during warm periods in mid-winter. We have observed a preoviposition period in this species of six to twenty days. The eggs usually hatch in less than twenty-four hours, the larvæ begin migrating from the food two to five days later. Pupæ are formed three to twelve days after hatching. The pupal period ranges from five to sixteen days and the total developmental period from eleven to

twenty-four days. These records were also made when the temperatures were comparatively high. When low temperatures prevail often the prepupal stage may be greatly delayed, sometimes lasting for several weeks.

Phormia regina.—This is the common black blow fly which is seen entering houses, cellars, etc., during the cool days in late fall and early spring. It appears that this species is much better adapted to cool climates than those previously discussed. In fact, in the southern states this form practically disappears with the coming of hot weather, and is not seen again until the cooler days of autumn. At the latitude of Dallas, specimens of this fly have been observed frequently in mid-winter resting in sunny places. This species, like the others, is largely a carrion feeder and after the appearance of cool weather in the fall it largely supplants Chrysomyia and the Lucilias as a scavenger, continuing to breed throughout winter.

The adults begin depositing in seven to eighteen days after escaping from the puparia. The egg stage varies much with the temperature, ranging from less than twenty-four hours up to nearly four days, as recorded by us. The duration of the larval stage is from four to fifteen days, the pupal stage from three to thirteen days, and the total developmental period ten to twenty-five days.

Calliphora erythrocephala.—This species is not abundant in Texas, but is fairly numerous in the eastern part of the state. The flies of this species were observed by us to begin depositing eggs in twelve to seventeen days after emergence. The incubation period is twenty-four hours, and the larvæ begin to migrate from the food three or four days after hatching. The pupal stage lasts from seven to nine days. The time from deposition of eggs to the emergence of adults ranges from fifteen to twenty days.

Cynomyia cadaverina.—This is the large blue bottle fly which in association with *Phormia regina*, appears in Texas after the heat of summer has passed. It is notorious as a frequenter of pantries and cellars where it avails itself of every opportunity to deposit eggs on food products of an animal origin. It is not averse to depositing on smoked meat, although uncured meat, especially if cooked or becoming rancid, seems to be preferred. The first eggs are deposited from seven to twenty days after emergence of the adult; these hatch in one or two days and the larvæ, which are ravenous feeders, begin entering the soil three to five days later. Puparia are formed five to thirty-nine days after the larvæ hatch, and the duration of the pupal stage ranges from six to fifty-eight days, as shown by our tests. The time occupied for the complete development of the insect, from egg to adult, ranges from thirteen to ninety-nine days.

Summary of Control Measures Suggested

The fact that carrion breeding flies have been looked upon largely as beneficial insects on account of their habits as scavengers and the failure to associate in the minds of ordinary individuals, these scavenger flies and the flies which infest living animals and food, it is rather difficult to secure the adoption of remedial measures based upon the prevention of fly breeding in decaying animal matter. Nevertheless, this is the key to the whole system of control. The presence of screw worms in the southwest has come to be looked upon by stockmen as a necessary evil and year after year they continue to practice the treatment of infested animals without giving any attention to the sources from which the myriads of flies come.

The appearance of anthrax or charbon among herds in portions of Texas has, under the laws, compelled the destruction of animals dying from this disease. Many stockmen have, out of fear of the malady, proceeded to burn all dead animals, and this has had a salutory effect on the screw worm situation in some sections. Destruction by burning is the preferred method of disposing of carrion. In many cases, however, this work is not thoroughly done and the partially consumed carcass continues to breed out flies. An objection to this method of disposing of animal matter is that in some sections wood is very scarce, hence the burning is rather costly. Crude oil or kerosene may be largely substituted for wood in such cases. Other objections to the feasibility of the destruction of carcasses on the large ranches in west Texas are the difficulty of finding the dead animals until at least one brood of flies has been produced and the fact that carcasses of wild animals may also breed considerable numbers of flies, but these do not nearly offset the protection derived from the consistent destruction of animals which are promptly located after death. It appears that where Chrysomyia and other species are prevented from increasing to great numbers, the chances of living animals being attacked are almost negligible.

Second to the burning of carcasses comes burying. Our experiments indicate that it is necessary to cover a dead animal, which has become infested with maggots, to a depth of at least two feet in order to prevent the completion of development and the emergence of flies. If animals are buried before they become infested this depth may be greatly reduced, as a few inches of soil well packed over a carcass will prevent adult flies or their offsprings from reaching it.

In order to prevent infestation of man or animals, protection of wounds from the flies is essential. Man, especially when subject to chronic catarrh, should not sleep in the open without protection by a fly

net, hospitals should be carefully screened, and wounded animals may be placed in screened stalls or have the wounds treated with pine tar or other repellent substances. As has been said, infestation of wounds which are produced by branding, dehorning, etc., may be prevented by arranging to do this work during winter. If possible, even in winter it is well to choose a period when the weather is cool. The prevention of infestation of sheep at lambing time may be accomplished to some extent by lambing as early in the spring as feasible without danger of severe storms. Of course the careful surveillance of all live stock during the fly season is imperative.

The methods of treating infested animals, as now practiced by stockmen, seem to be fairly satisfactory. Of the larvæ destroyers, chloroform is best as it has great penetrating power. Pine tar is one of the best substances to place on the wound to prevent further infestation after the larvæ have been destroyed. Certain mixtures, many of which contain carbon bisulphid, are being put up and sold by druggists for the purpose of destroying the larvæ and at the same time preventing reinfestation. The fact that carbon bisulphid is somewhat attractive to the adult flies renders the use of this substance inadvisable.

The careful disposal of slaughterhouse offal by burning or deep burying, the screening of abattoirs, and the use of screens wherever animal food products are kept, will largely prevent the contamination of these articles by the various blow flies. In cities the complete disposal of garbage with incinerators is desirable.

The relationship to this group of flies of certain mammals and birds which act as scavengers is a subject of much interest and importance, but space will not permit of its discussion here. We have also found that climatic conditions may be important in controlling this class of flies. The sun often destroys a large percentage of the maggots developing on a carcass. Where dead animals are not burned or buried it is important to leave them in open places exposed to the sun rather than in the shade of thickets, as is commonly practiced.

KEROSENE TRAPS AS A MEANS OF CHECKING UP THE EFFECTIVENESS OF A POISONED BAIT SPRAY TO CONTROL THE MEDITERRANEAN FRUIT-FLY (CERATITIS CAPITATA WIED.) WITH A RECORD OF BENEFICIAL INSECTS CAPTURED IN THE KEROSENE.

By Henry H. P. Severin, Ph.D., and Harry C. Severin, M.A.

Italian, French and South African entomologists gave striking demonstrations of the effectiveness of the poisoned bait spray in the control of different species of Trypetidæ, and all obtained a great

reduction of infested fruit on those trees that were sprayed. Mally[4] in 1909, gave a decisive demonstration of the success of this remedy to combat the Mediterranean fruit-fly under South African conditions. "A severe outbreak of the pest in a commercial peach orchard was brought to a sudden and practically complete halt, and the fruit maturing later was marketed under the guarantee of freedom from maggots, . . . while that of untreated trees a few hundred yards away increased until practically every fruit was involved."

In a series of experiments on the use of petroleum, vegetable and animal oils to trap the Mediterranean fruit-flies, we found that ordinary kerosene (about 120° Bé.) captured more fruit-flies than any of the other oils, with the possible exception of distillate (about 48° Bé). As distillate is too volatile for practical purposes it was decided to use traps containing kerosene as a means of checking up the effectiveness of a poisoned bait spray employed in the control of the Mediterranean fruit-fly.

When the Mediterranean fruit-flies issue from the pupæ, the eggs are undeveloped and the adults require from ten to twelve days before the egg-laying period begins. This period may be termed a *feeding period* and during this time the flies subsist on the waxy coating of fruit, juices of injured fruit on the trees or infested, fallen fruit on the ground. Our attention was also called to the fact that the Mediterranean fruit-fly feeds upon flowers of a chrysanthemum imported from Japan, but the pest was not attracted to these flowers in any great abundance. After a rain the fruit-flies were frequently seen lapping up droplets of water on the leaves. In captivity the flies show a fondness for diluted molasses and they would feed on this liquid until their abdomens became greatly distended. The greediness of the adults for sweets is the weak point in the life history of the pest and explains why the sweetened, poisoned sprays are so effective in the control of this insect. After the eggs are fully developed in the ovaries, the insect is seized by a reproductive stimulus and then not only seeks a suitable medium in which to deposit its eggs but also continues to search for food. This period, which may be called a *reproductive* and *feeding period*, commences at the time the eggs are fully developed and continues until the last egg is deposited.

In our work the poisoned bait was prepared according to the following formula, which is slightly modified from that recommended by Mally:

Brown sugar	2½ lb.
Arsenate of lead	5 oz.
Water	4 gal.

The solution was prepared by dissolving the brown sugar through a cheese-cloth bag in cold water so as to strain out all foreign material including ants, which in the Hawaiian Islands frequently gnaw through the paper sacks containing the sugar. The mixture was thoroughly agitated by pumping the liquid back upon itself with a common, garden, brass spray-pump. This pump was provided with a rose sprinkler nozzle which throws a mist-like spray (Pl. 13).

To determine the effectiveness of the poisoned bait spray as a means of controlling the Mediterranean fruit-fly under Hawaiian conditions the following plan of procedure was adopted. For a period of five weeks, ten kerosene traps were wired to the branches of citrus trees of an orchard containing about four hundred orange, lemon, grapefruit, banana, fig, guava, papaia, peach, pear, pepper, plum and mango trees. No spray was applied to any of the trees and vegetation in the orchard during this period and exact data were kept concerning the number of fruit-flies and beneficial insects found dead in the oil traps. During the following five weeks, the poisoned bait was sprayed once a week upon all of the fruit-bearing trees and again a record was kept of all the Mediterranean fruit-flies and beneficial insects captured in the traps. A comparison of the number of fruit-flies caught in the kerosene traps before, during and after spraying would test the value of the fruit-fly remedy.

The following table shows the number of male and female fruit-flies which were captured in the oil traps at intervals of from two to four days for a period of five weeks before spraying:

TABLE I

NUMBER OF MALE AND FEMALE MEDITERRANEAN FRUIT-FLIES CAPTURED IN TEN KEROSENE TRAPS AT INTERVALS OF TWO TO FOUR DAYS FOR A PERIOD OF FIVE WEEKS BEFORE SPRAYING

	♂	♀
Oct. 8– 9, two days' catch	683	2
Oct. 10–11, two days' catch	631	0
Oct. 12–13, two days' catch	454	0
Oct. 14–16, three days' catch	734	3
Oct. 17–20, four days' catch	1,090	1
Oct. 21–24, four days' catch	1,150	0
Oct. 25–28, four days' catch	1,622	6
Oct. 29–Nov. 1, four days' catch	986	3
Nov. 2–4, three days' catch	951	2
Nov. 5–7, three days' catch	491	7
Nov. 8–11, four days' catch	1,411	12
Thirty-five days' catch	10,203	36
	36	
	10,239 Total	

Average { 291 males captured per day. / 1 female captured per day. / 292 Total.

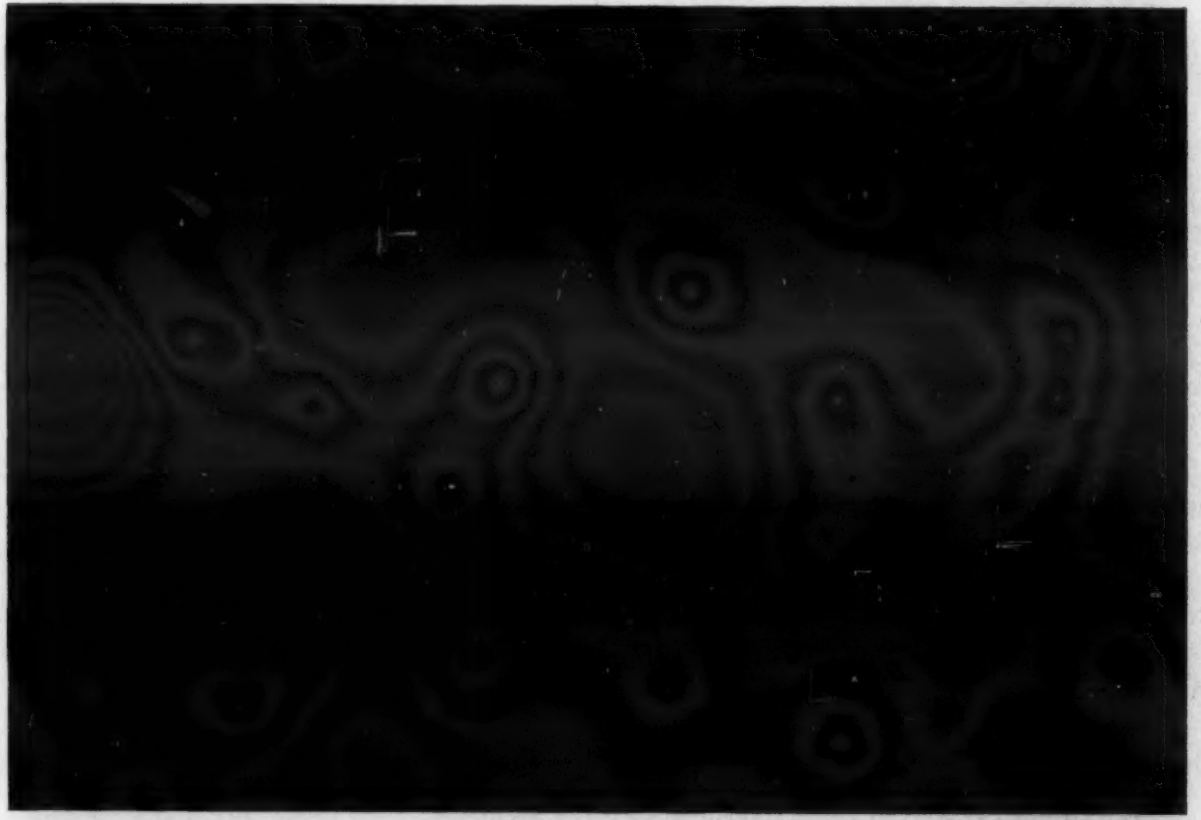
From this table it is readily seen that kerosene used in traps as a control for the Mediterranean fruit-fly is entirely out of the question, for the number of fruit-flies captured during the last four days is not smaller than the number caught during the first four days. Furthermore, of the 10,239 flies captured, only 36 were females, the remainder being males. And again, at the end of the fifth week almost every ripe orange was "stung" by the pest.

During the next five weeks the fruit-fly spray was applied to all of the fruit-bearing trees, about once a week, under the most unfavorable weather conditions. The applications of the spray were made during the rainy season and since this orchard is situated on the outskirts of Honolulu in Manoa Valley where rains are more frequent than in the city itself, the effectiveness of the poisoned bait was to receive a most thorough test. The rains were so frequent in this valley that the spray rarely remained on the leaves of the trees more than a day or two at the most and in one instance only a few hours before a rain fell. Hundreds of fruit-flies were present in this orchard before the application of the first spray and at this time it was an easy matter to capture several hundred specimens in an hour by sweeping with an insect net among the orange trees. This orchard was not isolated but was adjacent to a very much neglected orchard which was also teeming with the pest. Horticultural sanitation was not rigidly practiced throughout this entire experiment. All fallen, infested, citrus fruits, however, were collected daily and thrown into a barrel containing water, but since the larvæ of the pest are able to live for several days in fruit submerged in water, the fruit was removed from the barrel from time to time and burned. The wind breaks of this orchard consisted of high guava trees but very little of the fallen fruit from these trees was destroyed although the same was infested. Papaias, plums and tomatoes were allowed to decay on the ground. The following table shows the number of fruit-flies which were captured in the traps during and after spraying:

TABLE II

NUMBER OF MALE AND FEMALE MEDITERRANEAN FRUIT-FLIES CAPTURED IN TEN KEROSENE TRAPS AT INTERVALS OF TWO TO FIVE DAYS FOR A PERIOD OF FIVE WEEKS DURING AND AFTER SPRAYING

	♂	♀
After first spraying, Nov. 12–14, three days' catch	51	2
After first spraying, Nov. 15–17, three days' catch	40	0
Six days' catch	91	2
After second spraying, Nov. 18–21, four days' catch	12	1
After second spraying, Nov. 22–23, two days' catch	0	1
After second spraying, Nov. 24–26, three days' catch	8	0
Nine days' catch	20	2



Applying the poisoned bait, in the form of a mist-like spray, with a common garden, brass spray-pump provided with a rose sprinkler nozzle

After third spraying Nov. 27–30, four days' catch	2	2
After third spraying Dec. 1– 3, three days' catch	0	0
Seven days' catch	2	2
After fourth spraying, Dec. 4–5, two days' catch	1	0
After fourth spraying, Dec. 6–10, five days' catch	25	1
Seven days' catch	26	1
After fifth spraying, Dec. 11–13, three days' catch	23	0
After fifth spraying, Dec. 14–16, three days' catch	12	1
Six days' catch	35	1
Thirty-five days' catch	174	8
	8	
	182 Total	

Average { 5 males captured per day. / 1 female captured in about every 4 days.

A comparison of Tables I and II shows that there were 10,239 fruit-flies captured before spraying and only 182 during and after spraying, a reduction, therefore, of 10,057 specimens. Of the 182 Mediterranean fruit-flies captured during and after spraying, 93 were caught during the first six days, and 89 during the following twenty-nine days. After the application of five sprays, it usually required a thorough search to find an infested orange in the orchard, whereas before spraying, almost every ripe orange had been "stung" by the pest. See plate 14.

For a period of five weeks after December 16, no spray was applied to any of the trees in the orchard where the previous work was done but the ten kerosene traps were still kept wired to the same citrus trees. The following table shows the number of fruit-flies taken in these traps during this time:

TABLE III

INCREASE IN THE NUMBER OF MEDITERRANEAN FRUIT-FLIES CAPTURED IN TEN KEROSENE TRAPS FOR A PERIOD OF FIVE WEEKS AFTER SPRAYING WAS DISCONTINUED

	♂	♀
Dec. 17–20, four days' catch	23	0
Dec. 21–24, four days' catch	46	0
Dec. 25–27, three days' catch	37	0
Dec. 28–31, four days' catch	85	0
Jan. 1– 4, four days' catch	81	0
Jan. 5– 8, four days' catch	70	0
Jan. 9–12, four days' catch	92	1
Jan. 13–17, four days' catch	97	0
Jan. 18–21, four days' catch	134	0
Thirty-five days' catch	665	1
	1	
	666 Total	

Average { 19 males captured per day. / 1 female captured in 30 days.

A comparison of Tables II and III shows that the Mediterranean fruit-flies had again increased in numbers during the five weeks in which no spray was applied to the fruit trees. An examination of the fruit trees of this orchard after these five weeks had elapsed showed that some of the fruit had again been "stung." Trapping the pest with kerosene was continued in this orchard in connection with other experiments, and fifteen weeks after spraying was discontinued, 642 fruit-flies were captured in three days in the ten traps, or an average of 214 per day.

The gradual increase in the number of Mediterranean fruit-flies in this orchard after spraying was discontinued may be attributed to a number of causes: (1) horticultural sanitation was not rigidly practiced and many trypetids emerged from the fallen, infested fruit; (2) this orchard was not isolated but was adjacent to a very much neglected orchard from which probably many flies migrated; and (3) fruit-flies breeding in the wild fruits, covering thousands and thousands of acres in the mountainous districts, were probably caught up by the winds and carried into this orchard. We [5] have published the results of an experiment on the flight of two thousand marked, male, Mediterranean fruit-flies and have demonstrated that marked specimens, set free from the side of a mountain at an elevation of 350 feet, were carried by the prevailing winds. Some of these marked insects were captured in kerosene traps in this orchard, a mile from the point of liberation.

After taking Weinland, California's representative stationed in Honolulu, into an orchard and showing him our methods of checking up the effectiveness of the poisoned bait spray by means of kerosene traps and the results obtained, this entomologist carried on a similar experiment in a residential section of Honolulu. Weinland [6] sprayed only the low host trees, for with the apparatus at hand "it was impossible to spray higher than ten feet." He plotted a curve in checking up the efficiency of the spray with the use of kerosene traps and writes, "From the shape of the curve, it is apparent that there is a marked but temporary reduction in the number of flies caught. The lowest point comes about five days after spraying, after which time the spray becomes ineffective and flies coming in from outside sources raise the number again."

In our work, Mally's [4] formula of the poisoned bait spray was adopted but with this difference, Mally used three ounces of lead arsenate and we increased the amount from three to five ounces after the application of the first spray. The amount of poison was increased in our work in order to kill the flies more rapidly by giving them a greater dose of poison. To determine the length of time that fruit-

flies will live in captivity with leaves picked from trees sprayed with the bait containing three ounces of poison, thirteen fruit-flies were captured, some of which were actually observed feeding on the bait in the field. These flies were placed in jars together with the sprayed leaves suspended by threads at different heights. From time to time water was sprayed on the sides of the jars. The results of the experiment were as follows: Nine fruit-flies succumbed to the effects of the poison at the end of the first day, one by the end of the second, but the remaining three flies were still alive at the end of the third day.

When the fruit-fly spray has been properly applied to the trees, there is no conspicuous show of the bait from a distance, but a closer examination of the treated trees shows thousands and thousands of droplets of the spray adhering to the leaves and branches. These droplets, even after the water has evaporated, will not show the white traces of lead arsenate to the naked eye. If the solution has not been kept thoroughly agitated, the lead arsenate will sink to the bottom of the receptacle containing the mixture and the last few pump-fulls of the spray will contain an excess of lead arsenate. When this material is applied to the foliage, the lead arsenate in each droplet will settle as a white deposit, but this will be covered by a glossy layer of sugar after the water has evaporated (Pl. 14, fig. 2.) A rain may now wash off the sugar layer from the lead arsenate deposit and then, of course, the white specks become more conspicuous. These may adhere to the leaves for several weeks. In order to keep the finely divided particles of lead arsenate in suspension in the solution, every second pump-full of the spray was forcibly emptied against the bottom of the container.

After the trees in the orchard had been sprayed for the fifth time our attention was called to the fact that the leaves of the grapefruit and peach had been injured by the spray. The leaves showed evidence of brown areas as if they had been burned; later the leaves began to fall from the trees and in the case of the peach almost entire defoliation occurred. In the first two sprays, lead arsenate in paste form was used, but with the last three sprays the powdered lead arsenate was used. No attempt was made to determine the cause of the scorching of the leaves under Hawaiian conditions.

Shortly after the trees had been sprayed, a loud buzzing became audible as one walked through the orchard. Hundreds of insects, including house flies, bluebottle flies, syrphids, flesh flies, tachinids, mud daubers and paper wasps, hymenopterous parasites, long-horned grasshoppers, moths, an occasional butterfly, etc., were flying about sucking up the poisoned bait.

In several bulletins [1, 3] Mally claims that in South Africa "honey bees have paid no attention to the thin film of sweets on the leaves of

treated trees." In the Hawaiian Islands, however, we found that the spray does have a drawback from which Mally claims it was exempt—it does attract the honey bees. In one experiment fruit trees were sprayed which were not flowering but which were in the immediate vicinity of others that were in blossom. Honey bees were visiting these flowers in large numbers. Several hours later honey bees were observed feeding on the poisoned bait which was on the leaves of the treated trees, and also on the leaves of some shrubs and grass beneath the trees.

Mally [1] also claims that "citrus trees in blossom were sprayed . . . to determine the likelihood of destroying honey bees but in no case was a bee seen to feed on the poisoned sweet. It is possible that the blossoms were so much more attractive that the bait was no temptation." In the Hawaiian Islands, some of the honey bees will desert the best honey-producing flowers and seek the poisoned bait. At different times during the year when the algeroba, avocado, various kinds of citrus trees, papaia and peach trees were in blossom, these trees were sprayed with the fruit-fly remedy. Many honey bees, which had been observed visiting the flowers before spraying, left the flowers after spraying and were seen lapping up the deadly solution.

A record was kept of all beneficial insects, such as ladybird-beetles, staphylinids or rove-beetles, stylopids or strepsipterons, lacewings, tachinids and hymenopterous parasites which were captured in the kerosene. The following table shows a list of insects that were caught before, during and after spraying:

TABLE IV

LIST OF BENEFICIAL INSECTS CAPTURED IN TEN KEROSENE TRAPS BEFORE, DURING AND AFTER SPRAYING

Before spraying	PREDACEOUS INSECTS	During and after spraying
	Coccinellidæ	
2	Coccinella repanda Thunb.	7
9	Cryptolæmus montrouzieri Muls	16
20	Orcus chalybeus Boisd.	13
3	Platyomus lividigaster Muls.	2
4	Rhizobius ventralis Muls.	14
1	Vedalia cardinalis Muls.	0
1	Scymnus vividus Sharp	0
1	Sticholotus punctatus Crotch	2
41		54
4	Coccinellid larvæ	4
7	Staphylinids	3
1	Lacewing larva	0
53		61

Average about 2 per day.

PARASITES

Stylopidæ or Strepsiptera

1	Elenchus melanias Perkins	0

Tachinidæ

3	Frontina archippivora Will	2
2	Chætogædia monticola Bigot	1
5		3

Hymenoptera

571	Tetrastichus hagenowii (Ratzeb.) (Secondary parasite)	57
6	Anastatus kœbelei Ashm.	17
7	Solindenia picticornis Cam	1
2	Chalcis obscurata Walk	0
1	Pimpla hawaiiensis Cam	3
3	Ischiogonus palliatus (Cam.)	0
0	Encyrtus fuscus How	3
0	Cremastus hymeniæ Vier	1
590		82

19	Primary parasites	25
571	Secondary parasites	57

A large number of hymenopterous parasites which have not been identified were captured in the kerosene. Many parasites of which the hosts are unknown were trapped. Parasites new to the Hawaiian Islands, and of recent, accidental introduction, were caught in kerosene and other oils.

Besides the Mediterranean fruit-flies, predaceous and parasitic insects listed, a number of animals other than insects were caught in the kerosene; viz., one lizard, centipeds and many spiders. Of the insects captured, the largest number were (1) Mediterranean fruit-flies, (2) ants, (3) winged plant lice, (4) gnats or midges (in one catch 84 gnats or midges were counted), (5) bark lice and (6) moths. Among the Orthoptera, cockroaches, katydids, long-horned grasshoppers and one African mole cricket were taken in the oil. Among the Diptera, syrphid flies, soldier flies, vinegar flies, flesh flies and a few mosquitoes were killed in the kerosene. A few other insects that were found dead in the kerosene and worth mentioning on account of their economic importance are, the Japanese beetle (*Adoretus umbrosus*), Lantana leaf-bug (*Teleonomia lantanæ*), and Torpedo bug (*Siphanta acuta*).

It may be possible that some insects which have been captured with oil lamps are not attracted to the light but to the oil. According to Dr. Perkins, "It is just possible that Stylopidæ are attracted by kerosene, since one or two species have been taken in the oil on lamps, and are supposed to have been attracted by the *light*, but it may have been the *oil*."

We are indebted to Dr. R. C. L. Perkins of the Hawaii Sugar Planters' Association Experiment Station for the identification of the predaceous and parasitic insects.

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[1] Mally, C. W., 1904. The Fruit-Fly (*Ceratitis capitata* Wied.). Repr. Agric. Jour., Dec., No. 28, Cape of Good Hope, pp. 1–18.

[2] Mally, C. W., 1908. The Fruit-Fly. Paraffin Remedy versus Poisoned Bait. *Ibid*, No. 18, pp. 1–5.

[3] Mally, C. W., 1909. Poisoned Bait for Fruit-Fly. *Ibid*, No. 14, pp. 1–15.

[4] Mally, C. W., 1909. The Mally Fruit-Fly Remedy. *Ibid*, No. 49, pp. 1–6.

[5] Severin, H. H. P. and Hartung, W. J., 1912. The Flight of Two Thousand Marked Male Mediterranean Fruit-Flies (*Ceratitis capitata* Wied.). Annals of the Entomological Society of America V, No. 4, pp. 400–7.

[6] Weinland, H. A., 1912. The Present Fruit-Fly Situation and some Results of the Hawaiian Campaign. California State Commission of Horticulture Monthly Bulletin I, No. 1, pp. 845–852.

Explanation of Plate 14

Fig. 1. The two bottles on the right contain 10,239 Mediterranean fruit flies; these were captured in ten kerosene traps during five weeks before spraying. The bottle on the left contains 182 fruit flies and these were captured in ten kerosene traps wired to the same trees during and after spraying in the following five weeks.

Fig. 2. Leaf showing small droplets of spray. In this instance the solution was not kept thoroughly agitated and consequently the last few pump-fulls of the poisoned bait contained a large amount of the lead arsenate. The droplets of spray show a white deposit of lead arsenate covered with a glossy sugar layer; the latter is represented in black in the photograph.

[Last of the papers read by title.—Ed.]

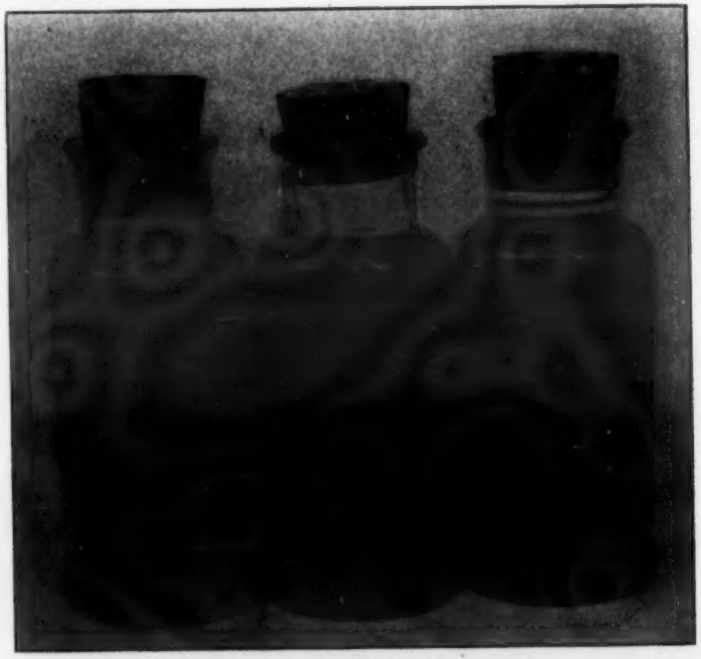
A CONTRIBUTION TO THE LIFE HISTORY OF THE CORN-FEEDING SYRPHUS FLY (MESOGRAMMA POLITA SAY)

By C. H. Richardson, *New Jersey Agricultural Experiment Station*

During the summer of 1913, the writer observed an infestation of *Mesogramma polita* which extended over a considerable portion of two hundred acres of sweet corn at Jobstown, Burlington County, N. J. The prosecution of other field work made it impossible to study the activities of this Syrphid in detail at that time. However, observations were made at frequent intervals and the results are given here as an addition to our present knowledge and a stimulus to further interest in this species.

References to the habits of *Mesogramma polita* are few. Riley and Howard,[1] who have given the most complete account of its life history,

[1] Insect Life, Vol. 1, 1888, pp. 5–8.



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report it from Griggstown, Somerset County, N. J., and Jacksonville, Fla. In the former locality, the larvæ were feeding on pollen from corn; in the latter they were attacking the corn tissue at the base of the leafstalk and were even found in soft discolored places in the stalk. Mr. Ashmead, who made the field observations at Jacksonville, states that he did not observe any of the larvæ feed upon pollen in that locality. In 1889 the same authors[1] published a letter from a correspondent at Cadet, Mo., in which damage to corn by the larvæ of *M. polita* was reported. In this locality, the informant found the larvæ between the bases of the leaves and the stems where they caused the lower leaves to wither and dry up.

The late Dr. John B. Smith cites an infestation in evergreen sweet corn at Cologne, Atlantic County, N. J.[2] The larvæ were found between the leaves and the stalks of the corn. Specimens kept in the laboratory lived apparently upon the moist exudation from the surface of the stalk where it envelops the leaf sheath. No pollen was given them, but they reached maturity successfully.

Sanderson in 1900[3] discovered this species in corn at Newark, Del. The larvæ were often found in the staminate flowers, in the axils of the leaves, in the silk and wherever else pollen had lodged. Puparia were observed among the florets on the tassels. Although the larvæ were very abundant, no injury to the leaves or stalks could be detected.

Folsom[4] has given the only account which the writer has seen of the aphidophagus habits of the corn-feeding Syrphus fly. He says, "*Mesogramma politum* is frequent in our clover fields, the green larva feeding on the clover-louse. A full-grown larva found on the ground March 27 made its puparium the same day, and the fly issued indoors April 8."

Metcalf[5] has considered a large part of the literature which relates to this species and has given observations made at Raleigh, N. C. In this locality he mentions that the pupæ were fastened to the tassels of the corn (p. 30).

SEASONAL DISTRIBUTION.—This Syrphid was first observed at Jobstown in a field of metropolitan sweet corn the last week in August when adults and larvæ were abundant, which would indicate that the breeding season was well advanced at that time. During September, the infestation spread to practically all of the fields. On October 11, the

[1] *Loc. cit.*, Vol. 2, p. 115.
[2] Rept. Ent. Dept. N. J. Agr. College Exp. Sta., 1899, pp. 442–443.
[3] Rept. of Entomologist, Delaware Exp. Sta., pp. 202–205.
[4] Univ. of Ill. Agr. Exp. Sta., Bull. 134, p. 148.
[5] Syrphidæ of Ohio, Ohio State Univ. Bull., Vol. 17, No. 31, 1913, pp. 16–88.

number of flies had decreased perceptibly. Those seen were mostly males and the few females observed were not ovipositing. Pupæ were still present. After this date field work was discontinued.

FEEDING HABITS OF THE ADULTS.—Adults of both sexes seemed to feed exclusively upon pollen from the corn. Feeding was done in a more or less systematic manner. The flies would often hold an anther with their fore legs and, beginning at one end, would consume the pollen along its whole length.

The females were easily approached while they hovered about the tassels and it was not difficult to catch them with forceps when at rest. The males, however, exhibited a greater "shyness," and could rarely be obtained in this manner.

OVIPOSITION.—Most of the eggs were deposited in groups in the staminate flowers, although a few, reposing singly, could be found on the leaves and other parts of the plants. The groups, which were always found on the inner surface of the glumes, contained as few as two or as many as nineteen eggs. The actual number laid by a single female was not ascertained.

The female, when ready to oviposit, alights on a stem, moves along until a suitable flower is reached whereupon she reverses her position and feels the way with her ovipositor to the inner surface of the glumes.

FEEDING HABITS OF THE LARVÆ.—Young larvæ were found in the staminate flowers, but seemed to leave them after a short time and to collect in greatest abundance in the axils of the leaves. Many were also seen in depressions along the midrib of the lower leaves where pollen had accumulated. That they fed largely on pollen was corroborated by actual observation and by examinations of the digestive tract. Larvæ were often seen in the silk, but never as abundantly as in the axils of the leaves. Just prior to pupation, the larvæ usually abandoned the axils of the leaves and wandered about over the plant.

No deleterious effects of the larvæ upon the corn were noticed at Jobstown and in this respect these observations are in harmony with previous studies in New Jersey and Delaware. Whether or not the larvæ in the axils of the leaves fed upon plant exudations was not ascertained, but it was certain, if such feeding occurred, it did not appreciably injure the corn. Nor was there evidence to show that enough pollen was consumed to reduce the yield in the experimental plots where other studies were under way.

PUPATION.—On September 12, a count was made to determine the preferred place for pupation with the following result:

Along midrib, upper surface of leaf	31	pupæ.
Along midrib, lower surface of leaf	4	"
On blade of leaf, upper surface	13	"
On blade of leaf, lower surface	1	"
At tip of corn ear	5	"

Other pupæ were found at later dates in the axils of the leaves, and in the sheath surrounding the ear, but they were invariably more numerous on the upper surface of the leaf. Sanderson and Metcalf have observed many pupæ on the tassels, but this was certainly not the preferred place for pupation at Jobstown.

NATURAL ENEMIES.—The most important enemy of the corn-feeding Syrphus fly was a disease which appeared to be particularly fatal to mature larvæ. Dead individuals were to be seen on nearly every corn leaf and on the stalks in places where the larvæ were particularly numerous. Sanderson mentions an apparently similar epidemic in Delaware.

While a larva of *Megilla fuscilabris* was found but once in the act of devouring a pupa of *M. polita*, there can be no doubt that it was an active enemy of the corn-feeding Syrphus fly because of its abundance in the corn fields and the large number of pupal remnants which showed the visitation of a predaceous insect.

Although a large number of pupæ were reared and many dissected, no internal parasites were found. In a few cases, eggs placed on leaves showed holes through which egg parasites had escaped.

DISCUSSION.—*Mesogramma polita* has apparently never been injurious to corn in New Jersey or Delaware. Reports of injury have come, however, from Florida and Missouri and it seems that the feeding habits of this species will require closer attention in many localities before its exact economic status can be determined.

The observations of Folsom are particularly important because they indicate a hitherto unknown feeding habit for this species. If *M. polita* proves to be commonly predaceous then Metcalf's acceptance of it as a purely phytophagous species cannot be upheld. The close relationship of the genus *Mesogramma* with the aphidophagous genera, *Syrphus* and *Sphærophoria* as indicated by Riley and Howard [1] and the general resemblance of the larva to other predaceous Syrphid larvæ suggest its derivation from predaceous ancestors. This conception is further strengthened by the fact that *Mesogramma marginata* Say [2] is also predaceous in habit.

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[1] *Loc. cit.*, 1888.

[2] Folsom, *loc. cit.*

The present data suggest that the species is sporadic in its attacks upon corn. There are but three recorded outbreaks in the state of New Jersey for the period from 1885 to 1914, although New Jersey was one of the first states in which its presence on corn was noted. It may be that the corn-feeding habit is only occasional and that the larvæ normally lead a predaceous existence well hidden among close-growing vegetation.

LIFE HISTORY, NATURAL ENEMIES AND THE POISONED BAIT SPRAY AS A METHOD OF CONTROL OF THE IMPORTED ONION FLY (PHORBIA CEPETORUM MEADE) WITH NOTES ON OTHER ONION PESTS[1]

By HENRY H. P. SEVERIN, PH.D., *Wisconsin Agricultural Experiment Station*, and HARRY C. SEVERIN, M.A., *South Dakota State College of Agriculture and Mechanic Arts*

I INTRODUCTION

As onion growers in some parts of Wisconsin have been forced to give up the business of growing onions on account of the ravages of the imported onion fly (*Phorbia cepetorum* Meade), an investigation was started to determine the life history, natural enemies, probable causes of the enormous increase of the pest and the value of the poisoned bait spray as a method of control. In this paper a few observations on other onion pests will also be noted. A more detailed paper on the imported onion fly and other insects injurious to onions will appear in the Wisconsin Academy of Sciences, Arts and Letters.

II LIFE HISTORY

In the process of oviposition the imported onion fly usually endeavors to force its ovipositor between the onion stem and the ground, but when the earth is tightly crusted against the plant, the egg-laying organ is unable to penetrate the hardened soil. The female fly may then oviposit in a crevice near the onion stem, or if a small crack is not available, the pest will sometimes crawl in holes or under lumps of dirt an inch or two from the onion plant to deposit its eggs.

The eggs are usually deposited from one-eighth to one-fourth of an inch below the substratum, and are glued to either the soil or stem. Sometimes the eggs may be found above the surface of the ground attached to the stem, within the axil of a leaf or to the leaves themselves. The number of eggs which are laid at one deposition may vary from one to fifteen.

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[1] Permission has been granted by Director H. L. Russell of the Wisconsin Agricultural Experiment Station for the advanced publication of this paper.

Under field conditions the incubation period of eggs deposited by the first brood of flies in early June varied from three to four days. The larval period was completed in two to three weeks in green onions, onion-sets and small seeded onions, but in seeded onions from the previous year, the development of the maggots was often prolonged and, in some instances, required from four to five weeks. The pupal period under field conditions required from nine to sixteen days during the latter part of June and early July, the majority of the second brood of flies emerging in eleven, twelve and thirteen days.

Several experiments were performed to determine whether the imported onion fly could complete its life history in food material other than the onion. In one instance, fourteen eggs immediately after deposition in an onion field, were placed below the surface of the soil in contact with radishes growing in a flower pot. Fourteen onion flies completed the different stages of their life cycle in twenty-nine to thirty-five days in the radishes. In a second experiment freshly laid eggs were transferred from onions to manure. The next day the eggs were shriveled in appearance and an examination of the manure disclosed the presence of numerous mites, that had undoubtedly sucked the eggs dry. The experiment was repeated but this time fresh horse droppings were used. The different stages of the life history in the manure were completed in twenty-nine to thirty-one days, except one fly which required fifty-two days to pass through the egg, larval and pupal periods.

An attempt was made to determine the number of days required after emergence of adults from puparia before fully developed eggs appeared in the ovaries. A large number of adults of the second brood, which emerged on the same day, were confined in breeding jars containing onions planted in wet sand. The specimens were fed daily on diluted molasses, and water was sprayed into the jars with an atomizer. Daily dissections of specimens confined in breeding jars showed that one of ten females had ripe eggs in the ovaries at the end of twelve days, but other females did not show mature eggs in the ovaries at the end of sixteen days. In all probability, the effect of confining the insects in breeding jars as well as the food material employed, played an important rôle in the rate of development of the eggs.

Through dissections of female flies of the first and second broods, it was found that the average number of apparently full-grown eggs present in the ovaries varied from forty-one to fifty-one. In all probability, the onion fly empties its ovaries of a batch of about fifty eggs, depositing from one to fifteen eggs at a time, a second batch of eggs probably then develops, ripens, and is deposited and so on.

The period of emergence of the second brood of onion flies under field conditions extended from June 28 to July 25, most of the flies

issuing from July 1–12. We determined by a series of daily dissections of twenty flies which were captured by sweeping the onions with an insect-net, when the second brood is about to oviposit in the onion fields. On July 10, 55 per cent of the females dissected contained almost fully-developed eggs in the ovaries. Two of the twenty specimens dissected on this date had already deposited eggs, for only two ripe eggs were found in the ovaries of one female and three were present in the other.

III Natural Enemies

The most important natural enemy of the onion maggot in Wisconsin is a Staphylinid or rove beetle (*Aleochara anthomyiæ* Sprague). On July 1, three hundred imported onion fly puparia were sieved from the soil in a green onion bed. From July 16–30, twenty-seven (9 per cent) Staphylinids emerged, whereas the last onion fly issued on July 13, from these puparia. When an onion maggot is dropped into the breeding jar near the Staphylinids, the larva is seized by the mandibles of the beetles and the Coleoptera tenaciously cling to the wriggling maggot as the victim is being devoured. In the field masses of onion fly eggs were found which had been partly devoured by some predaceous enemy, and it may be possible that the Staphylinids preyed upon these eggs.

Two wasps (*Oxybelus 4-notatus* Say), each dragging an onion fly, were captured in an onion field on July 21. In all probability, this wasp sometimes provisions its nest with this pest.

Spiders were frequently observed sucking out the juices of the imported onion flies. These spiders were commonly seen lying in wait for their prey at the union of two onion leaves.

A single Hymenopterous parasite was bred from an imported onion fly puparium on August 31. On June 25, the parasitized onion fly larva pupated under laboratory conditions. Mr. J. C. Crawford, U. S. National Museum, identified this parasite as, "*Cothonaspis* n. subg." This is due, he states, "to its having only 11 joints in the antennæ instead of 12 or 13 as the various subgenera of Cothonaspis have. However, there is only one specimen, and he is loath to describe it as a new subgenus since occasionally these vary and this might be a specimen with abnormal antennæ." A number of specimens of another Hymenopterous parasite were bred from puparia obtained from larvæ which completed their development in radishes. This parasite was placed in the genus Cothonaspis by the same specialist. Mr. F. Knab, U. S. Bureau of Entomology, identified two species of Anthomyids which were bred from radishes, the seed-corn maggot (*Phorbia fusciceps* Zett.) and the cabbage maggot (*Phorbia brassicæ* Bouche).

In all probability, the last mentioned parasite attacks both species of Phorbia.

In the field onion flies which had succumbed to the effects of a fungus disease were frequently found adhering to onion leaves. In the laboratory the disease was spread to healthy flies confined in breeding jars.

IV Probable Causes of Enormous Increase of Imported Onion Fly

After a large number of commercial onion fields were visited and the methods employed by the growers were observed, it soon became evident that there are a number of reasons why the onion fly has increased to such enormous numbers in Wisconsin. The most favorable conditions for the multiplication of the pest rests in the fact that no steps are taken to destroy the maggoty onions in the fields. Most of the onion growers pay no attention to clean field methods.

As there was a low market for onions in the fall of 1912, many of the growers stored their seeded onions in warehouses over winter, with the expectation that a better price could be obtained in the spring. During the winter many farmers experienced difficulty with the onion rot (*Sclerotium cepivorum*) and all diseased onions were dumped on the land. In the spring there was no market for the onions and the bulbs were dumped and plowed under in the fields. One grower used 18,000 bushels as a fertilizer. Some of these onions sprouted early in the spring, offering the first brood of flies a most favorable opportunity to oviposit before the onion seeds germinated. It was common to see these onions growing here and there in sugar beet and potato fields. In fields where onions had been grown the previous year and where rotation of crops was practiced, hundreds of eggs of the pest were obtained by removing the soil in contact with the onion stems. An examination of the decaying bulbs plowed in the soil showed the presence of numerous maggots. Puparia were found in the soil beneath these decayed onions and the second brood of onion flies emerged from June 14–20; whereas, in the case of infested green onions under a cage in the field, the second brood issued from June 28 to July 25, most of the flies issuing from July 1–12.

When the onions are so seriously infested that the crop is not worth harvesting, the growers simply plow under the maggoty onions, thus giving the pests a most favorable opportunity to complete their life history.

During the marketing of the crop many infested, decayed and injured onions are thrown in the fields. In grading the onions, the men throw out of the screen all infested, decayed and injured bulbs.

These maggoty onions are allowed to remain in the fields thus giving the larvæ an opportunity to complete their development, bore into the soil to pupate and issue as flies.

The methods of harvesting seeded onions and onion-sets are different and have an important bearing on the destruction of the onion refuse. After the leaves of seeded onions ripen down and shrivel, the bulbs are removed from the ground. A few days later the leaves are cut off with grass shears and the tops are allowed to remain on the ground. After the onions have been removed from the fields, the tops and the maggoty, decayed, injured and under-sized onions can be accumulated in piles and burned.

In harvesting onion-sets the leaves are cut off with a lawn mower or grass shears before the bulbs are removed from the ground. The tops are gathered in windrows or piles and soon begin to decay. An examination of this decaying onion refuse showed the presence of numerous dipterous larvæ. Some of the growers labor under the impression that the onion waste will not burn. We have demonstrated to a number of farmers that no kerosene or fuel need be consumed if this work is properly carried out. The onion refuse left in windrows and piles will not burn, for it decays and becomes soaked with rain. If, on the other hand, this material is scattered in the field, the leaves lose what little moisture they retained during the ripening of the onion-sets, and then all the refuse can be accumulated in piles under favorable weather conditions and burned.

Too much emphasis cannot be expressed concerning the importance of clean field methods in the control of the onion thrips. When the onion tops become dry in the fields, the winged thrips leave the refuse and spread to the neighboring vegetation, reinfesting the onions when these are planted the following season. An examination of the onion tops several weeks after the crop was harvested showed the presence of numerous thrip larvæ beneath the sheaths of the onion leaves. These immature, wingless thrips would have been destroyed if the onion refuse had been burned immediately after the crop was harvested.

Many onion growers do not practice crop rotation. Some growers have planted onions on the same tract of land for a period of twelve successive years. Most of the onion growers in southeastern Wisconsin are not in favor of crop rotation, and grow onions on the same land year after year until the onion smut and insect pests render onion growing unprofitable.

Fall plowing is not practiced by many of the commercial onion growers in southeastern Wisconsin. In some cases the crop is barely harvested when about three carloads of Chicago stock yard manure to an acre is scattered over the onion refuse. Fall plowing would crush

many of the onion fly puparia and expose others to the sunshine and these, in all probability, would fail to hatch. Many puparia would probably be destroyed by natural enemies, such as birds and Carabids.

V. Poisoned Bait Spray

Although seventy methods of fighting root maggots have been put on record, no attempt has been made to poison, with a sweetened spray, the adult before the egg-laying period begins. Under natural conditions the imported onion flies were observed feeding on wild and cultivated flowers, onion leaves and soil. In captivity *Phorbia cepetorum* relished diluted black-strap molasses, and they fed upon this sweetened liquid until their abdomens became greatly distended. If this insect is attracted to diluted molasses under natural conditions, the greediness of the flies for this sweet when poisoned, would be the weak point in the life history to attack the pest. If this poisoned bait be applied in the form of a spray to the onion leaves when the imagoes first appear on the wing and if the Anthomyids were to feed upon the insecticide no doubt large numbers would be killed before the egg-laying period commences.

A series of experiments were performed to determine the length of time that the imported onion flies would live in captivity when fed with diluted black-strap molasses to which had been added different kinds and amounts of insoluble poisons. Some of the flies were still alive at the end of a week in these experiments even though the poisoned bait was applied daily within the jars. The following proportions of molasses and water were used with each poison:

¼ pint molasses.
1 or 2 ounces arsenate of lead, or zinc arsenite.
1 gallon water.

A series of similar experiments were now performed with different quantities of sodium arsenite, a soluble poison. One gram of sodium arsenite dissolved in a gallon of water sweetened with one-quarter of a pint of molasses, killed the onion flies within a day; in fact, a few specimens succumbed to the effects of the poison at the end of three hours. Too much emphasis, however, should not be attributed to any of these experiments, because the insects were in captivity and in feeding were forced to consume the poisoned bait.

In our field work, the first application of the spray was given to the onion leaves to control the second brood of flies on July 10, 1913. The poisoned bait was applied with a hand pump provided with a vermorel nozzle. The minute droplets of the spray adhered to the waxy coating of the onion leaves without a "sticker" being added to the poisoned

diluted molasses. After half an onion field was baited we were convinced that thorough spraying was not necessary, *as there was no question of doubt that the diluted molasses clearly attracted this pest.* In the sprayed portion of the onion field, numerous flies were seen on the onion leaves feeding on the minute droplets of this insecticide until their abdomens became greatly distended, but in the unsprayed part of the onion field, rarely was an Anthomyid seen exposed to the sunshine on the tops of the onion leaves. The following formula was used in this experiment:

Molasses	½ pt.
Sodium arsenite (dissolved in boiling water)	½ oz.
Water	1 gal.

Four applications of the spray were made to control the second brood of onion flies in this somewhat isolated onion field in which the pest had already destroyed 50 per cent of the crop. The bait was renewed once during each week.

On account of the severe thrip injury to the onion leaves in this field it was difficult to determine whether the waxy coating of the leaves insured protection from the burning of the soluble poison.

The results obtained were most encouraging in this somewhat isolated onion field for few infested onions were found compared with the ravages of the pest in some of the onion farms in the vicinity. As the season's work was started too late to test the effectiveness of the poisoned bait against the first brood of the pest, which is probably more difficult to combat on account of the frequent spring rains which wash off the spray, no conclusions can be drawn from the good showing that the spray made against the second brood.

To control the imported onion fly in a commercial onion field which is surrounded by other infested onion farms, may present a more difficult problem on account of the invasion of the pest from adjacent fields. It may be possible that if one grower sprays and his neighbors do not, that a few applications of the bait to the entire onion field followed by spraying of the margins adjacent to the unsprayed fields, may control the invading flies. This work must be continued during a number of seasons to determine whether the pest can be controlled in non-isolated onion fields.

VI Black Onion Fly (*Tritoxa flexa* Wied.)

According to Chittenden[1] the black onion fly (*Tritoxa flexa* Wied.) is "an old enemy of the onion and a native species, recorded from the

[1] Chittenden, F. H. Insects Injurious to Vegetables, p. 245.

Altantic coast to Illinois." Two black onion flies were taken by the writers in Milwaukee County, Wisconsin, on June 12, 1902. In the year 1913, nine of these insects were captured in Racine County, Wisconsin, and one specimen was bred from an infested onion on August 27. The black onion fly was not a serious pest of the onion in the season of 1913.

VII Barred-Winged Onion Fly (*Chætopsis ænea* Wied.)

The barred-winged onion fly (*Chætopsis ænea* Wied.) was bred from decaying and also smut-infected onions.

VIII Euxesta notata Wied.

Another Ortalid (*Euxesta notata* Wied.) was commonly reared from decaying and smut-infected onions and from piles of decaying onion tops. The maggots of this insect were often found feeding in company with the larvæ of the imported onion fly or in decaying or partially decayed onions which the latter had deserted.

IX Onion Thrips (*Thrips tabaci* Lind.)

The first noticeable injury to onion plants caused by the onion thrips (*Thrips tabaci* Lind.) was observed at the end of June. At this time thrips were especially abundant between the two central or innermost leaves. Considerable alarm was expressed by the onion growers during the prolonged hot dry spell at this time of the year, as enormous numbers of the pest began to appear in the onion fields. On July 4, the dry spell was broken by a driving rain which according to the statements of the commercial onion growers, "destroyed great numbers of the insect and saved the onion crop." In the month of August, however, the leaves showed severe thrip injury, namely, the whitened appearance of the leaves produced by the rasping and sucking mouth-parts of the insects.

X Cutworms

Cutworms caused a slight amount of injury in the onion growing districts near Racine, Wisconsin, in 1913. The damage to onions by these pests was principally the work of the spotted cutworm (*Noctua c-nigrum* Linn.) and the variegated cutworm (*Peridroma saucia* Hbn.). The spotted cutworm was so heavily parasitized by a parasite, *Apanteles* (*Protapanteles*) sp. in 1913, that but little injury was caused to the onions by the pest.

XI Miscellaneous Insects Injurious to Onions

Among the miscellaneous insects injurious to onions observed occasionally in the onion fields were the following: Zebra caterpillar

(*Mamestra picta* Harr.), yellow-bear caterpillar (*Diacrisia virginica* Fab.), white-lined sphinx (*Deilephila lineata* Fab.), tarnished plant-bug (*Lygus pratensis* Linn.), and twelve-spotted Diabrotica (*Diabrotica 12-punctata* Oliv.).

XII Insects Bred from Decayed Onions

A number of insects breed in onions after the imported onion fly larvæ have caused decay. Stable fly (*Stomoxys calcitrans* Linn.) larvæ were found feeding in company with the imported onion fly maggots, or in decaying onions which the latter had deserted. The adults were often reared under field and laboratory conditions.

Glischrochilus (*Ips*) *fasciatus* Oliv., and its larvæ were observed feeding in decaying onions, which were or had been infested with the imported onion fly larvæ. The beetle and its larvæ were commonly found in decaying onions which had been plowed under as a fertilizer.

NOTES ON THE BROWN LACE-WING[1]

(*Hemerobius pacificus*, Bks.)

By Geo. F. Moznette, *Oregon Agricultural College*

A study of the above species was begun in the early part of November, 1913, and numerous observations have been made in the field, while breeding experiments have been conducted in the laboratory.

This species, a member of the order *Neuroptera*, is of considerable economic importance in that it is predaceous in its larval stage upon the *Aphididæ* or plant lice, *Acarina* or mites, and probably other soft-bodied insects. It was found to be particularly important in destroying the oviparous females of the Rosy Apple Aphis, *Aphis sorbi* Kalt., and the Currant Aphis, *Myzus ribis* Linn. However, this species preys upon almost all species of *Aphididæ*, and during July, 1913, it was found quite abundant in hop yards feeding upon the wingless females of the summer generations of the Hop Aphis, *Phorodon humuli* Schrank, and also on the Red Spider of the Hop, *Tetranychus telarius* Linn.

Specimens in the college collection are recorded from Vale in eastern Oregon, and Corvallis and Oregon City in western Oregon. It is an important economic species in California, and is also found in the states of Washington, New Mexico, Arizona, and the province of British Columbia. We can then assume that it is distributed over the Pacific Coast regions.

[1] This article is published with the permission of Prof. H. F. Wilson as a contribution from the Entomological Department of the Oregon Agricultural College.

The determinations of the Aphids used were made by Prof. H. F. Wilson to whom I am also indebted for suggestions in this work. The determination of the lace-wing was made for this department by Mr. Nathan Banks, of the United States National Museum, Washington, D. C. He described this species in his paper entitled New North American Neuropteroid Insects, Transactions of the American Entomological Society, XXIV.

On November 3, 1913, numerous eggs and larvæ were found among colonies of *Aphis sorbi* Kalt. on apple trees in the experimental orchard of the Oregon Agricultural College. The eggs are laid singly on the lower surface of the leaves. They may be found placed indiscriminately over the lower leaf surface, but most of them are deposited next to the midrib, lateral vein or in the axil of the two. They are laid horizontally or on end, usually the former.

The egg is ovoid, white, changing to a light amber in the course of development and growth, and measures .92 mm. in length and .40 mm. in width. The surface is reticulated and at one end is located a small disc-shaped micropyle.

On November 29, 1913, a number of apple leaves free from eggs were tagged on a small apple-tree. Many eggs were found in the orchard on this date. The tagged leaves were observed each day and December 1, 1913, three leaves were found each with a single egg. These leaves were placed in vials to ascertain the incubation period. The eggs developed, and hatched on December 10, 1913, the duration of the egg stage being nine days.

The newly hatched larva is somewhat different from that of the mature larva in that it is distinctly white in color, and the mouthparts are much more prominent than in the later instars. The eyes are a faint brown. It measures 2 mm. in length. Upon hatching, the larva emerges from the egg at one end, and remains motionless for a very short period, after which it immediately becomes very active in search of food.

The larva moults three times, twice before spinning its cocoon and once just before it transforms to the pupa. The third larval exuvium is found in the cocoon. I have observed that the larvæ of *Hemerobius pacificus* develop much more rapidly in warm than in cool weather. Under the latter conditions, they seem to become more sluggish and show a reluctance to feed. The larvæ did not show any real disposition to cover themselves with Aphis skins, though they frequently became entangled in the hairs and feet, and were involuntarily carried about.

The larvæ were supplied with an abundance of Aphis, consisting of *Aphis sorbi* Kalt., *Macrosiphum lycopersici* Clark; and *Amphorophora*

lactucæ Kalt. The latter is very common in the fall on a species of milkweed around Corvallis, Oregon. On approaching an Aphis the larva makes a quick dart for it, inserts its piercing mouthparts, and sucks the blood from the victim.

The accompanying table gives some data on the life history of three of the larvæ.

DURATION OF THE VARIOUS STAGES

Larva No.	Hatched	1st moult	2nd moult	3rd moult	Pupated	Emerged
1.....	Nov. 22, 1913	Nov. 26, 1913	Nov. 28, 1913	Dec. 7, 1913	Dec. 7, 1913	Dec. 21, 1913
2.....	Nov. 11, 1913	Nov. 15, 1913	Nov. 20, 1913	Nov. 22, 1913	Nov. 22, 1913	Dec. 8, 1913
3.....	Nov. 22, 1913	Nov. 26, 1913	Nov. 28, 1913	Dec. 6, 1913	Dec. 6, 1913	Dec. 21, 1913

The duration of the larval stage and instars varies considerably according to the nature and quantity of the food supply and the rapidity with which it feeds. Also the temperature. The larval period was found to average fourteen days.

The larva is sort of spindle-shaped, tapering toward the caudal end. The mature larva measures 7.5 mm. in length. The head is strong and bears large sharp curved grasping and blood sucking mouthparts. The antennæ are composed of three annulated segments, the rings being very close together and not distinct so that several cross lines occur connecting the different rings. The eyes are dark brown and almost black. A dark brown line runs through the eyes as well as the center of the head. The legs are whitish and the feet possess suckers which are sort of bell-shaped and located between the claws. The abdomen is light amber in color with darker markings. On each side of the dorsal aspect there is a discontinuous line, each thoracic, and the first few anterior abdominal segments possessing an irregularly shaped marking, brown in color. These markings are intersected by the thoracic and abdominal sutures. There is also a line which runs down the center of the dorsum from the head to the cauda. The underneath parts are pale amber colored fading to a whitish color approaching the sides. The larva is slightly pubescent. The sucker at the caudal end of the abodmen is used, as in the case of the larvæ of the *Coccinellidæ*, for anchorage.

When ready to pupate, the larvæ as a rule seek some crevice in the bark, although cocoons were found in clustered leaves of apple curled by Aphis, and on the under surface of the leaves of currant and hop vines. Anthracnose cankers on trunks and limbs of apple trees make desirable places for hibernation. Each larva upon finding a suitable place immediately begins to construct a very thin, loosely woven cocoon. When the cocoon is constructed it continues contracting, moults for the last time and pupates. The cocoon is 5 mm. in length.

The pupa is a light brown in color, the thoracic and abdominal regions bearing the same characteristic markings as are found in the larva. It is somewhat cylindrical in shape curved and with the limbs and wings folded to the breast. The wing pads are at first white changing to a light amber in color. The antennæ are now more or less clavate, the segments not distinctly bead-like. The eyes are very prominently black. It measures 4 mm. in length.

The insect on emerging from the cocoon ruptures one end, and the pupa apparently cuts its way out of the cocoon as the pupal skin is cast outside. The length of the pupal stage is fifteen days.

The adult is distinctly light brown in color, lighter at first, changing gradually to a darker shade and is covered with short hairs. The head is small and pale in color. The eyes are prominently black. There is a brown band below each eye. The antennæ are moniliform or bead-like in form. There is a brown line at the base of each antenna. They are pale amber in color. The thorax is pale and hardly brown. The legs and abdomen are a little darker. Wings hyaline, the venation is somewhat pale marked with brown spots which are darker at the base, rising from these spots are indistinct oblique clouds. The gradate veins are mostly brown clouded forming an indistinct band. Along the border are groups of brown spots and the pterostigma is indistinct. The costal space is narrow toward the base and the median is much bent toward cubitus at connecting veinlets. Three radial sectors, the upper branch of the third forked before the inner gradate series, lower simple. Last gradate veinlet of inner series is distinctly beyond the previous one. Hind wings white with pale veins except few outer gradate ones. Expanse 18–21 mm.

When at rest, which is usually during the day, the wings are held roof-like over the body. I have observed but few on the wing during the day and then only when disturbed from their place of rest. Their flight is slow and sluggish. When confined in breeding cages they do not live more than three or four days.

Records of the feeding of five *Hemerobius* larvæ are given as follows:

APHIDS EATEN BY HEMEROBIUS LARVÆ

Larva No.	Hatched	Number Aphids Devoured per Day									Total Aphids Devoured	Average per Day
		Dec. 11	Dec. 12	Dec. 13	Dec. 14	Dec. 15	Dec. 16	Dec. 17	Dec. 18	Dec. 18–19–20 in Cocoon but not Pupa until Dec. 22–23–24		
1.....	Dec. 10	10	26	24	25	26	24	29	32	.....	196	24
2.....	Dec. 10	13	27	28	27	29	23	28	29	.....	204	25
3.....	Dec. 10	19	29	28	29	30	25	26	30	.....	216	27
4.....	Dec. 10	12	26	27	28	25	24	28	31	.....	201	25
5.....	Dec. 10	10	23	23	24	26	23	29	33	.....	191	24

In studying this species, the experiments were conducted under laboratory conditions where the temperature varies. Temperature readings during day were between 60–80 degrees and during the night between 40–50 degrees Fahrenheit. Observations were made on forty-seven eggs, twenty-two hatched and transformed into adults. The life cycle according to observations under these conditions required an average period of thirty-eight days.

EXPLANATION OF PLATE 15

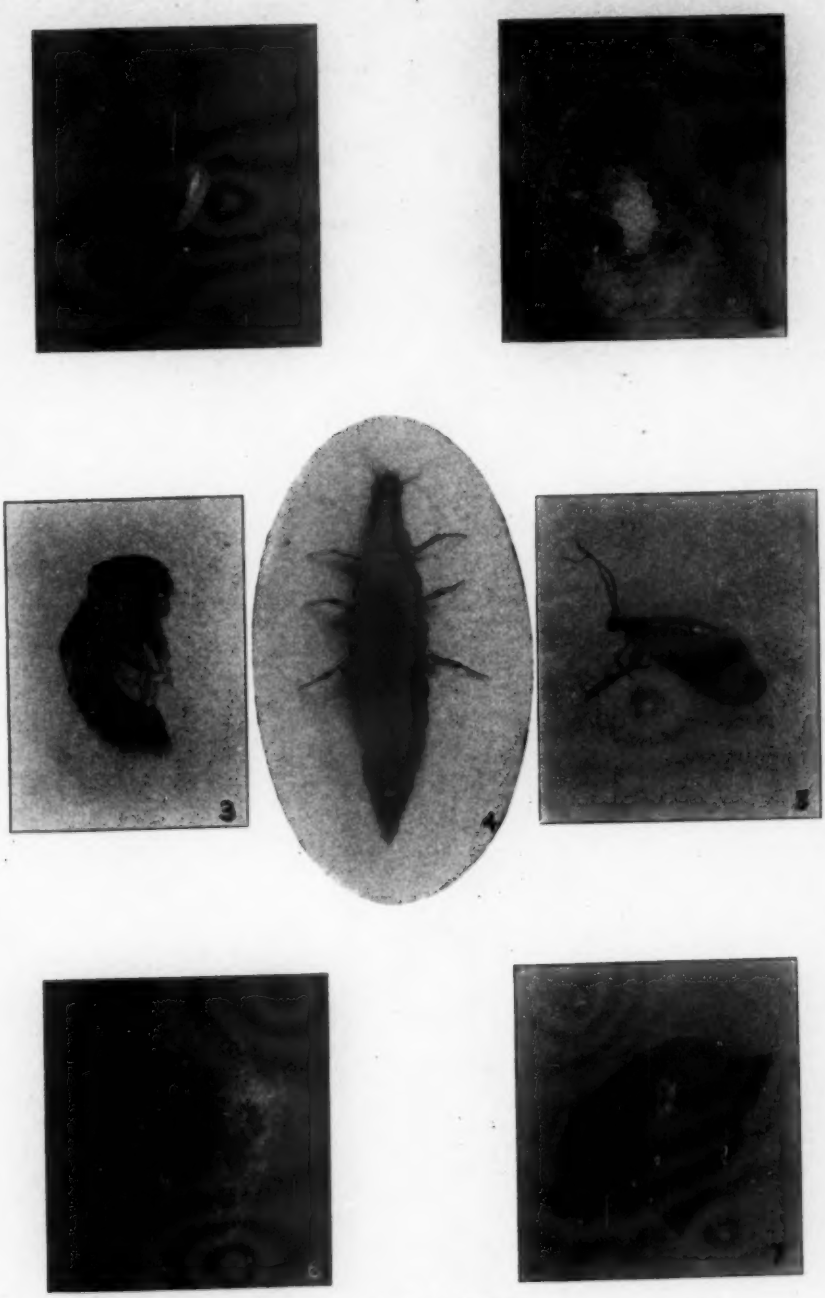
No. 1. The egg in situ on leaf. (Much enlarged.)
2. Cocoon. (Much enlarged.)
3. Pupa. (Much enlarged.)
4. Larva. (Much enlarged.)
5. Adult. (Much enlarged.)
6. Cocoon with top dissected away to show pupa. (Much enlarged.)
7. Showing pupa encased in cocoon. (Slightly enlarged.)

THE MOUTHPARTS OF THE THYSANOPTERA AND THE RELATION OF THRIPS TO THE NON-SETTING OF CERTAIN FRUITS AND SEEDS

By ARTHUR D. BORDEN, *Pasadena, California*

The asymmetry of the mouthparts of the Thysanoptera has been known for a long time, and a number of papers have been published describing in more or less detail the general characters of the mouthparts. In the present paper is presented a detailed account of the mouth structure of the thrips based on a considerable comparative study of the mouthparts. It also includes some observations on the feeding habits and on the damage done by certain of the economically important species. As examples of what serious pests are contained in this group of insects, there need only be mentioned the pear thrips (*Euthrips pyri*), the wheat thrips (*Euthrips tritici*), the orange thrips (*Euthrips citri*), the grass thrips (*Anaphothrips striatus*), the onion thrips (*Thrips tabaci*), the tobacco thrips (*Euthrips fuscus*), the greenhouse thrips (*Heliothrips hæmorrhoidalis*), and the bean thrips (*Heliothrips fasciatus*). Nearly all of these are recognized as pests in the state of California.

The earliest considerable description I have been able to find of the mouthparts is that of Karl Jordan (1888), on *Parthenothrips dracænæ*, a fairly accurate description and quite well illustrated. Then came the account of H. Garman (1890), on *Limothrips cerealium*, who points out the error in considering the articulated lobes of the maxillæ as the mandibles, and suggests that the unpaired organ is truly the mandible. In 1891 J. Bohls published as a doctor's dissertation at



Brown Lace Wing

Göttingen an account of the mouthparts. Then follows the account in Uzel's Monograph (1895) in which Uzel adopts Garman's views as to the structure, excepting that he differs with Garman in regard to the mandibles, Uzel holding that the lobes of the maxillæ are the mandibles and calling the mandible of Garman the epipharynx. Garman again presented his theory, in the *American Naturalist* (1896), and offered a strong argument to support his views. In 1899, Pietro Buffa, an Italian, described the structure of *Heliothrips hæmorrhoidalis*, giving a fairly accurate description, although his illustrations are confusing. Finally, in 1902, W. E. Hinds gave a very good description of the structure of the mouthparts of *Anaphothrips striatus*, but his figure is at most only diagrammatic. Very little comparative work had been attempted before the work of Hinds.

The present work is based on studies made of representatives of all three families of the Thysanoptera, including twelve of the genera and some twenty odd species. The material was all collected in the Santa Clara Valley, California. The method employed in collecting and preparing was as follows: The thrips were collected and killed by dropping them directly into 70 or 80 per cent alcohol; dehydrated by passing them successively through 90, 95 and absolute alcohol, then cleared in xylol and mounted in balsam. As soon as mounted, the mouthparts may be separated out by carefully pressing and moving the cover slip with a needle, under the low power of the compound microscope, until it can be seen that the parts are sufficiently separated. In some cases the specimens were cleared by boiling in KOH a few seconds before mounting.

The work and preparation of this paper were carried on in the Entomological Laboratory of Stanford University.

The Mouthparts

The mouthparts of the thrips appear as a broad unjointed cone attached to the extreme posterior edge of the under side of the head and carried so far back that it lies largely under the pronotum when at rest. The apex of the cone is usually quite sharp, as in many of the Phlœothripidæ, in which case the separate parts are longer and more tapering than where the tip of the cone is more blunt, as in many of the Thripidæ. The shape of the cone is not of the same type throughout any one large group or even for the different families, but varies greatly even for the different genera in the same family.

In the suborder Terebrantia, the mouthparts are connected to the frons by a strongly chitinized thickening rounding the head (Pl. 16, figs. 1, *e* and 2, *e*) which is more or less oblique on the front of the head. In this suborder there is also a strongly chitinized thickening extending

from this circular band to the left eye (Pl. 16, figs. 1, *b* and 2, *b*) and a rudiment of one under the right eye (Pl. 16, figs. 1, *a* and 2, *a*). At each side of the head and extending a short way down the side of the mouth cone is a peculiar curved spine which may possibly serve as a strengthening rod to the side of the cone (Pl. 16, fig. 2, *d*). The suborder Tubulifera has the connection with the eye wanting.

The general makeup of the mouthparts of the different species is quite similar, the greatest difference occurring in the shape of the parts in those species where the cone is blunt instead of sharp. In the former case, the separate parts are heavier and broader and necessarily shorter. There is also some difference in the number of segments of the labial and maxillary palpi, as will be noted later. The mouthparts of the young are similar to those of the adult, though less strongly chitinized.

As to the asymmetry of the mouthparts, I have adopted Garman's views and consider the unpaired organ on the left side as the mandible. The labrum and the clypeus also show asymmetry and these will be discussed separately.

LABRUM.—The labrum (Pl. 16, fig 1, *l*) forms the front of the cone and is asymmetrical in all the thrips. It is composed of two segments closely united and is distinguished from the clypeus (Pl. 16, figs. 1, *c* and 2, *c*) by a membranous connection. It is long, slightly curved and bears at the tip a round socket through which the stylets pass (Pl. 16, figs. 3 and 3, *a*). So far as I know, this condition has not been pointed out before. The labrum is drawn out on the right side and nears the edge of the clypeus. The clypeus is decidedly asymmetrical and curves high on the left side, thus forming the broad part of the membranous connection between it and the labrum.

MAXILLÆ.—The maxillæ (Pl. 16, figs, 1, *g* and 4) form the side walls of the mouth cone. They are triangular in form, and taper strongly towards their tips which fit closely about the tip of the labrum. About the middle of the maxillæ are borne the maxillary palpi (Pl. 16, fig. 4, *b*) which bear a few tactile hairs. The maxillary stylets, or lobes (Pl. 16, figs. 1, *i* and 4, *i*), are borne at the top and are jointed, being composed of a short stout arm and a long tapering stylet. By lowering the angle of the short arm with the main part of the maxillæ, the stylets are thrust out. The segments in the maxillary palpi differ greatly in number and shape with different genera, even in the same family. For example, in the family Aeolothripidæ, members of the genus Orothrips have seven segments, of the genus Erythothrips eight segments, and of the genus Aelothrips three segments. The usual number in the family Thripidæ is three although often only two occur. In the family Phlœothripidae the usual number is two.

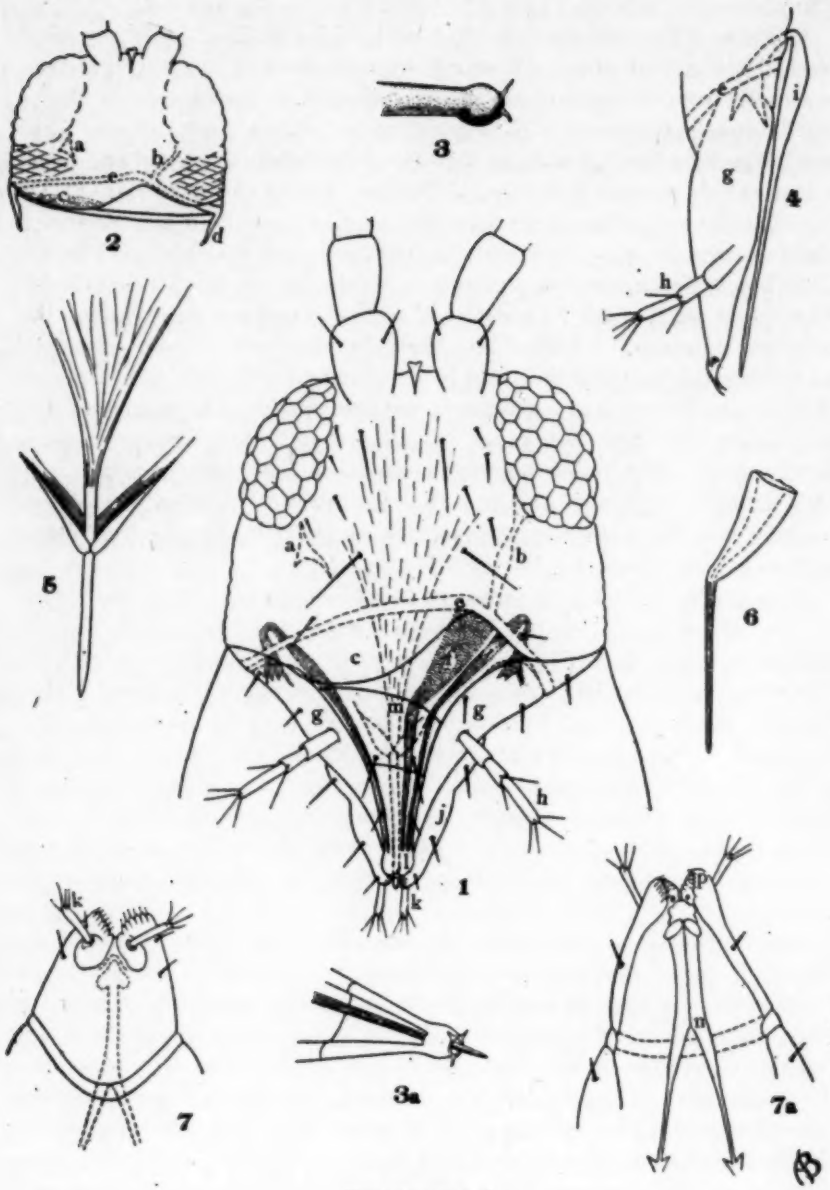
The segments may be short and stout, as in the genus Orothrips, or they may be long and cylindrical as in many of the genera of the Thripidæ.

LABIUM.—The labium (Pl. 16, figs. 1, *a*, 7 and 7, *a*) forms the hind wall of the mouth cone. Where the mouth cone is blunt, the labium is usually very broad and heavy, and where the mouth cone is sharp, the labium is narrowed. The labial palpi (Pl. 16, figs. 1, *k* and 7, *k*) are borne near the tip, and the very tip of the labium is lobed and bears a tactile hair on each tiny lobe. There is a strong chitinous bar (Pl. 16, figs. 7, *a–n*) extending down near the median line of the labium which divides near its base and ends in two peculiar, spear-shaped parts. This bar is undoubtedly a strengthening device for the fleshy labium. The labial palpi differ as greatly as do the maxillary palpi within the different families. In the Phlœothripidæ they are usually described as having but one segment and in the Thripidæ usually two, while in the family Oelothripidæ the genus Orothrips bears five segments and the others but four. In most Thripidæ that I have examined there seems to be but a single segment composing the labial palpus.

Within the hollow of this mouth cone we find the maxillary stylets already described, the single mandible on the left side, and an organ which I have taken to be the hypopharynx.

MANDIBLE.—This is a large, strongly chitinized, styliform organ on the left side (Pl. 16, fig. 1, *f*) and joined by its broad base to the chitinous band in the frons just where the connection is made with the bar running to the left eye. The mandible is peculiarly fitted to this side of the head, and I have been unable to find anything corresponding to it on the right side, though several authors have described a rudimentary part. Although the mandible may differ slightly in shape in the different groups, the structure is essentially the same throughout. It is made up of a bulbous chitinous base with a strong muscular attachment and a long sharp stylet slightly angled at its base.

HYPOPHARYNX.—Just below the mandible and on the base of the mouth opening, viewing the mouthparts from the front, is a large styliform organ passing through a groove or socket (which is attached to the floor of the mouth opening) and with a strong muscular attachment reaching well up under the frons of the head. This I take to be a hypopharynx. It has been only partially described before. Jordan describes the upper section and suggests that it is a hypopharynx; Buffa describes it in part and also figures an epiglottis; Hinds simply mentions it but does not attempt to describe it. In none of the accounts has it been described as styliform as I have found it in my preparations. This I take to be used much as is the mandible in feeding.



Euthrips tritici

Observations on Feeding Habits

The mouthparts of the Thysanoptera are probably used almost entirely for sucking although they have been repeatedly described as intermediate in form between those of sucking and chewing insects. In feeding, the insect begins by a forward and backward movement of the head and by this sort of rasping movement punctures the epidermal cells of the plant tissue. It then lowers its head and begins to suck up the plant juices. It remains here until the punctured cells are nearly emptied when it moves on a bit and repeats the operation. From the structure of the mouthparts it appears that the strong mandible and possibly the hypopharynx are used in breaking the cells of the tissues, while the finer stylets of the maxillæ are using in lancing the softer tissues. The tip of the labrum placed over the puncture forms a close connection and the juices are easily sucked up into the mouth. The whole mouth cone is fitted for sucking and most likely the food is almost entirely plant juices. I have made observations on the greenhouse thrips, *Heliothrips hæmorrhoidalis* and *Parthenothrips dracænæ* on leaves of a greenhouse plant, and also on *Euthrips pyri*, the pear thrips, on fruit blossoms, as well as *Euthrips tritici* and *Euthrips occidentalis* on alfalfa blossoms. The feeding habits of the young are similar to those of the adult.

Results of Feeding on Deciduous Fruits

On the deciduous fruits the thrips feed on the tender floral parts (the tips of the petals of the opening buds and later on the inner floral parts including the tender stigma) with very damaging results to the setting of the fruit, where the insects occur in any great numbers. The injured tissues at first turn brown and later black, often resulting

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Explanation of Plate 16

Fig. 1. Head of *Euthrips tritici:* *a*, rudiment of chitinous band to right eye; *b*, chitinous band to left eye; *c*, clypeus; *d*, chitinous band under frons; *f*, mandible; *g*, maxilla; *h*, maxillary palpus; *i*, maxillary stylet; *j*, labium *k*, labial palpus; *l*, labrum; *m*, hypopharynx.

Fig. 2. Same with mouth parts removed: *a*, rudiment of chitinous band to right eye; *b*, chitinous band to left eye; *c*, clypeus; *d*, curved spine from chitinous band; *e*-chitinous band.

Fig. 3. Tip of labrum, side view.

Fig. 3a. Tip of labrum, under-side showing stylets in position.

Fig. 4. Maxilla: *e*, part of chitinous band; *g*, main part of maxilla; *h*, maxillary palpus; *i*, maxillary stylet.

Fig. 5. Hypopharynx removed, showing socket and muscular attachment.

Fig. 6. Mandible removed.

Fig. 7. Labium ventral side.

Fig. 7a. Labium dorsal side, showing chitinous rod (*n*).

in premature falling of the flower before setting of the fruit. In the Santa Clara Valley I have examined peach blossoms which contained a great number of thrips and even before the fruit had had a chance to set the damage was so serious that by gently stripping my hand down a twig nearly every blossom would fall. The almonds, the first crop to blossom, are damaged to a slight extent where the thrips occur in numbers, but the prunes, plums, peaches, apricots and cherries, which follow in rapid succession, are the fruits which are damaged the most. This had been an unusual spring (1913) for thrips and they have done serious damage to crops in the Santa Clara Valley. One orchardist estimated that nearly two-thirds of the "set" on his peach orchard was destroyed by thrips this year. These trees are commonly infested with *Euthrips pyri*, *Euthrips occidentalis*, *Euthrips tritici*, and *Oelothrips kuwanaii*, though *Euthrips pyri* occurs in much the greater numbers.

Damage to Alfalfa Grown for Seed

On alfalfa I have collected quantities of *Euthrips tritici* and *Euthrips occidentalis*. Though alfalfa is not grown for seed in the Santa Clara Valley, I have had a chance to observe the work of the thrips, as the insects occur in considerable numbers there. The damage here is much the same as in the flowers of the deciduous fruits. The young floral parts are attacked, and the damage results in the premature falling of the flower or the young seed pod. Though the ovary is very pubescent I have observed thrips feeding about the base and also along the tender stigma. Often I have found specimens of alfalfa where nearly all the small pods had dropped from the main stem and only a few remained near the tip. Where this damage could not be directly traced to the feeding of *Diabrotica soror*, and the thrips were present in great numbers, the damage was most likely the result of thrips attack.

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FURTHER EXPERIMENTS IN THE CONTROL OF THE TARNISHED PLANT-BUG

Lygus pratensis Linn.

By M. D. Leonard, *Ithaca, N. Y.*

In June, 1914, Professor C. R. Crosby[1] and the writer published a bulletin on the tarnished plant-bug, in which were recorded the results, all negative in character, of experiments performed in a nursery near Rochester, N. Y., where the insect has been very destructive to peach stock. The conclusion was reached by the writers that:

"The foregoing experiments show that it is doubtful whether the injuries to peach nursery stock by the tarnished plant-bug can ever be prevented by the use of deterrents, or whether the adult bugs can be killed under actual field conditions by any contact insecticide now at our disposal. Catching the bugs by mechanical means has thus far been unsuccessful. Furthermore, either catching or killing the bugs in the nursery would be of very little value in protecting the trees, because of the invasion of the blocks by swarms of bugs from adjoining fields. It would seem that the only feasible means of preventing the injury to the trees would be either by excluding the adults from the nursery blocks by a wire screen fence, or by enclosing the tips of the terminals in bags during the period in which most of the injury is inflicted. It might also be possible to prevent some of the loss from this cause by assisting the trees to outgrow the injury by proper pruning and cultural methods." (Crosby & Leonard, 1914:497.)

The suggestions for future experimental work contained in the above statement were followed out in the same nursery during the past summer and it is the results of these experiments which are presented in the present paper.

Fencing

In order to thoroughly test the efficiency of excluding tarnished plant-bugs from the nursery blocks by means of a fence, an experiment was carried out using wire screen cloth on a much larger scale than that of the previous summer. It had been our experience during the seasons of 1912 and 1913 that the insects did not appear on the peach stock in any considerable numbers till about June 23, and that then,

[1] I wish to express my thanks to Professor Crosby, under whose direction the work outlined on this paper was done, for assistance in planning and carrying out the experiments.

within a few days, their numbers increased rapidly. Accordingly, in order to have the fence up and in working order by that date, its erection was commenced on the fifth of June. Ordinary wire screen cloth 6 feet wide was used to enclose a rectangular area 470 feet by 240 feet which therefore contained 2.59 acres. This enclosure was placed in a 13-acre block of peach "buds." A narrow strip of ornamentals bordered the fence on the west side; the other three sides were surrounded by peaches.

Hickory posts 9 feet long were sunk 2 feet into the ground at intervals of 10 feet. The wire screen cloth was then fastened to these uprights with heavy staples. In order to prevent any insects from crawling through open spaces at the bottom due to irregularities of the ground, the dirt was banked up firmly 3 or 4 inches at the base. At one corner a flap of the wire was arranged so that it could be opened in order to admit teams and workmen. Since the rows ran north and south, on the inside at the north and south ends the trees were dug out for a distance of about 10 feet in order to provide a turning place for the mules and cultivator.

It had been previously observed that though the tarnished plant-bugs did not actually fly over the fence from the surrounding weeds or nursery stock they would, however, fly onto the fence, crawl to the top and then fly into the enclosure. In order to prevent this a strip of O.& W. Thum's Tree Tanglefoot about 4 inches in width was applied along the upper edge of the wire cloth. The method of application was as follows: Two men worked together, one on each side of the fence. Wooden paddles were used, the ends of which were cut at an angle and bevelled. The tanglefoot was applied from the outside and pressed back and forth until a uniform thickness of about 1/10 inch was obtained, the man on the inside always finishing so that the greater part remained on the outside of the wire cloth.

It took two men about an hour to put on such a band of tanglefoot 100 feet in length. A pail of tanglefoot containing about 25 pounds covered about 300 linear feet.

In another part of the nursery in which about 13 acres of peach seedlings were planted, a similar fence was constructed but the enclosed area was much smaller, the dimensions being 190 feet by 100 feet. Most of the observations were made, however, at the larger enclosure as it was nearer to the laboratory. This enclosure was completed on the 12th of June and the smaller on the 16th.

The cost of construction of the two fences together, including materials and labor is shown in the following statement.

COST OF CONSTRUCTION

2,000 linear feet wire screen cloth, 72 inches wide, 12 meshes to the inch, at $1.70 per hundred square feet	$204.00
Tanglefoot, 175 pounds	30.00
Poles used for uprights, 200 at 5¢ per pole	10.00
Materials and labor	
Construction of fence, 145 hrs. at 20¢ per hr	29.00
Applying tanglefoot, 40 hrs. at 20¢ per hr	8.00
Mounding dirt at bottom, 5 hrs. at 20¢ per hr	1.00
Total	$282.00

The peach blocks were first examined on June 4 and at that date a tarnished plant-bug nymph in the third instar was found. On June 6, two adults were captured. On June 9, two adults were taken inside the enclosure and four outside; the following day two inside and none outside, and on June 10, two inside and one outside.

In order to determine whether tarnished plant-bugs were getting over the fence into the enclosure, careful counts were made at short intervals. There were 66 rows inside the enclosure, each about 450 feet in length. An equal distance was measured off on these same rows immediately south of the enclosure as a check plot. Every eighth row was selected and the number of tarnished plant-bugs occurring on each row recorded. The insects were caught by walking along the rows and sweeping the trees with an insect net. The following table is a record of these counts made from June 15 to July 24.

TABLE SHOWING THE NUMBER OF TARNISHED PLANT-BUGS CAUGHT PER ROW IN THE PEACH BLOCKS
Enclosure

June	15	17	18	22	23	25	26	30	Jy. 4	7	9	14	15	18	24
Row 1...	2	1	1	4	4	7	20	4	15	4	9	20	32	6	19
9...	0	0	1	3	0	4	6	4	11	12	23	25	22	3	22
17...	0	0	0	0	0	6	12	11	14	36	54	61	44	10	12
25...	0	0	0	0	3	5	12	13	21	76	112	60	50	25	13
33...	0	0	0	4	2	1	7	12	20	18	26	46	50	14	12
41...	0	0	0	0	6	3	6	4	17	13	26	29	60	17	25
49...	0	0	0	2	3	11	10	17	12	30	39	72	50	28	15
57...	1	0	0	2	2	6	11	23	31	78	78	81	59	22	11
65...	2	0	1	0	7	11	13	30	21	47	27	62	47	25	20
Total....	5	1	3	15	27	54	107	118	162	314	394	456	414	150	149

Check Plot

Row 1...	2	0	4	7	8	12	7	9	18	10	20	51	45	9	10
9...	0	0	2	6	2	20	6	17	21	6	62	111	60	30	16
17...	1	1	1	9	4	8	18	24	37	11	77	108	62	47	18
25...	2	0	6	5	9	34	24	34	24	46	78	87	88	26	30
33...	0	2	2	7	6	40	15	25	33	80	112	61	62	24	20
41...	1	1	2	20	7	32	21	29	54	29	150	123	125	34	17
49...	1	2	7	22	9	31	17	32	37	67	124	150	84	33	12
57...	0	0	0	17	4	18	12	25	53	99	146	140	67	8	22
65...	0	1	3	19	9	31	18	42	70	100	185	136	109	27	21
Total.....	7	7	27	112	58	226	138	237	347	448	953	967	762	238	166

It was at first proposed to count, at intervals of several days, the number of injured terminals on six rows inside the enclosure and on six rows of equal length on the check plot outside of the enclosure. The number of trees in each of these rows was therefore counted and the percentage of injured terminals was to be determined. The number of injured terminals was counted at intervals of 3 or 4 days but it was found that by the twenty-ninth of July about 75 per cent of the trees on the inside of the enclosure and of those in the check plot had been stung and the counts were discontinued. The number of injured trees increased at about an equal rate in both the enclosed and the check plot. The nursery was visited again on November 8 and there was about 95 per cent injury both inside the enclosure and on the check plot.

At the time the fence was erected the number of tarnished plant-bugs which had appeared in the nursery blocks was negligible. By examining the totals in the above table it may be seen that during the period in which it was under observation the fence did keep out many of the tarnished plant-bugs, in some cases over 50 per cent, but from the final condition of the trees inside the enclosure as seen on November 8 not enough had been excluded to make its use worth while.

The behavior of these insects on the fence was carefully observed from day to day. It was found that very few of the bugs would alight on the fence higher than three feet from the ground. They would then make their way to the edge of the tanglefoot by walking or by a series of flights of six or eight inches each. From this point it required but a short flight to carry the insect over the width of the tanglefoot and into the enclosure. Some, of course, did not act in this manner but after walking or flying about a little returned to the weeds or peach trees.

Although the tanglefoot band soon became filled with insects of many kinds—flies, beetles and bugs, it was noticed that practically no tarnished plant-bugs had been captured. Time and again these insects were seen to either crawl or fly onto the tanglefoot, walk about upon it, and then either crawl back onto the wire cloth or proceed to the top of the band and fly into the enclosure. This was not due to the fact that the tanglefoot did not remain sticky for it caught other insects constantly. But one tarnished plant-bug was observed to crawl through the meshes of the wire cloth and this one only when a cyanide bottle had been placed over it.

On November 8 the peaches were examined and when the enclosed block and the check block were compared as a whole no difference could be seen in the growth of the trees as affected by the tarnished plant-bug.

Bagging

When the tip of the leader on a peach nursery tree is "stung" by the tarnished plant-bug the upward growth of the tree is checked, the nourishment is thrown into the laterals, and a short bushy tree which has lost much or all of its market value is the result.

In July and August, 1913, preliminary experiments were performed in protecting the terminals of the peach trees from tarnished plant-bug injury by placing paper, mosquito netting and cheese-cloth bags over them. From the results obtained it seemed that it might be feasible to protect the tips by means of five-pound unglazed paper bags without injury to the foliage. Accordingly on June 18, 1914, before any of the tips had been stung, row 15 south and west of the fenced enclosure consisting of about 450 trees, was bagged with five-pound unglazed paper bags. These were placed over the tips so as to leave about three inches between the tip of the leader and the bottom of the bag in order to allow for some growth. The bags were folded once at the bottom so as to close the opening as completely as possible and fastened together with two pins. It was found that one man could put on 100 bags in slightly less than an hour.

On June 26 these bags were examined and it was seen that as the tips of the young trees were still tender they were being bent far over to the east, due to the weight of the bags and the constant west winds which continually blow over the nursery blocks. On this date 300 bags were placed on trees in the first row west of the enclosure.

On June 30 all the bags were removed as it was found that they were impeding the growth and destroying the shape of the trees. On row No. 1 the foliage under the bags was somewhat cramped, though not greatly so as they had been on only four days. The tips, however,

were badly bent over to the east and several were broken off. On row No. 5 in most of the cases in which the pins had not been stuck through several leaves the bags had been blown off. Those bags which still remained on the trees had bent the tips over at right angles or even farther. It was evident that it was wholly impracticable to place bags over the terminals at this date because they were as yet too tender to stand the strain due to the weight of the bags in the wind. This method of protecting the peach trees from the attacks of the tarnished plant-bugs was, therefore, abandoned.

Pruning

Phillips (1906) described a method of pruning to overcome a similar trouble of peach nursery stock. Although he attributed the injury to an undetermined species of mite, the system of pruning recommended by him would apply equally well if the injury were caused by the tarnished plant-bug. His experiments are as follows:

"He attempted to assist the tree to outgrow the injury by judicious pruning in May and June. On May 18, injured trees were pruned by pinching off the terminal bud, which had ceased to grow, giving one of the side shoots near the tip an opportunity to push up almost straight. The tips of the other laterals were also pinched off so as to throw the growth into the bud that was left at the top. On August 15 an examination showed that of the pruned trees, 68 per cent and 73 per cent of Wonderful and Champion, respectively, had grown straight. Unfortunately, no check is available for comparison, and it is also to be noted that only 13 per cent of the total number of trees were injured in the first place, which is a very much smaller percentage of injury than is common in nurseries in New York. On June 22, other trees of an unknown variety were similarly pruned, except that some of the lower laterals were cut off close to the trunk. In this case only twenty-five trees were treated. By the 15th of August, 88 per cent of the pruned trees had grown up straight." (Crosby and Leonard, 1914:491.)

Back and Price (1912:334) state that this method of pruning is "worthless during the period of greatest activity of *pratensis*, for as fast as a new shoot was formed, the terminal bud was at once killed." Quaintance (1912:108) quotes a letter from a Maryland nursery firm in which the following statement is made:

"The past summer we kept a gang of men going over our peach blocks and cutting or heading-in the side branches in order to throw the growth to the terminals and make them start a second growth. In this way we got our trees to start to grow and the most of them finally outgrew the trouble. We know no other remedy than to cut the side branches back two or three inches."

Because of the favorable results obtained in Maryland and Virginia it was deemed advisable to give this method of pruning the trees a trial. On July 29, injured trees in three rows were treated as follows:

Row a. Forty trees were pruned by cutting off the injured leader down to the first healthy lateral below it. Three or four of the other top laterals were then headed in 5 or 6 inches in order to throw most of the growth into the one chosen to continue the upward growth of the tree.

Row b. Fifty-seven trees in this row were similarly pruned except that about ten of the higher laterals on each tree were headed in.

Row c. Twenty-five trees were pruned in the same manner as were those in row *b* but in addition the lower laterals were cut off entirely to a height of about twenty inches. It is the practice in this nursery to trim off the lower laterals some time in August or later in the season, depending somewhat upon the condition of growth of the trees and the availability of labor. This last method was, therefore, simply the regular fall pruning made at an earlier date.

On November 9 the peach blocks were visited and the pruned trees examined. The results were, on the whole, unsatisfactory. The laterals of all the peach trees in the nursery had made good growth since they were last examined on July 29, due to plentiful rains in August. The weather during June and July had been extremely dry. However, no difference could be noticed between the amount of growth made by the pruned trees in rows *a* and *b* and the unpruned trees about them. In row *c* three or four of the pruned trees had practically outgrown the injury, these, however, constitute only about 12 per cent of the trees treated in this manner.

The early pruning of the lower laterals at such time as most of the tarnished plant-bugs will have left the peach blocks seems to give promise of aiding the trees to outgrow the injury. Much depends, however, on the condition of the weather and the amount of growth the trees make after being pruned. No further conclusions can be drawn as to the exact value of this operation until it has been tried out on a much larger scale.

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NOTE ON THE LIFE HISTORY OF ENCHENOPA BINOTATA SAY (MEMBRACIDÆ) ON THE BUTTERNUT[1]

W. D. FUNKHOUSER

Enchenopa binotata Say occurs in abundance in the vicinity of Ithaca, N. Y., on the butternut, and its life history on this host differs in some interesting respects from that which has usually been described for this insect.

The species is well known and widely distributed throughout eastern United States and its unique form and interesting habits have been productive of numerous references to its appearance. Dr. J. A. Lintner in 1882 described in some detail its habits and particularly its peculiar egg-mass in his First Report[2] and Matausch has given an excellent account of its usual life history with a complete series of drawings showing the froth-covered egg-masses, eggs, consecutive instars of the nymphs and views of the adults in his paper in 1912 in the *Journal* of the New York Society.[3]

The most characteristic feature of the life history of this species of membracid as compared with other Membracidæ is its peculiar habit of covering its eggs with a frothy mass which has often been confused with other insect deposits. The eggs are usually laid in two nearly parallel slits in the bark and the froth is placed over the slits in curious corrugated layers. This has often been observed on bitter-sweet, locust, grape and certain viburnums and on the hop-tree (*Ptelea trifoliata* L.) on which the insect appears to be particularly abundant and which Lintner states is its favorite host. The nymphs are gray-brown, sometimes tinged with greenish, and the adults light ferruginous brown with characteristic yellow bands on the pronotum. The males are usually darker than the females. These habits are to be noted commonly in this locality when the insect chooses for its host the locust (*Robinia pseudacacia* L.) or the bitter-sweet (*Celastrus scandens* L.) on both of which plants it is very common. Locally, however, the species is much more abundant on the butternut (*Juglans cinerea* L.) than on any other host, and it is on this tree that it deviates from its usual habits.

It was first reported as inhabitating the butternut by Fitch in 1851[4] but apparently its life history on this host has not been recorded. Here

[1] Contribution from the Entomological Laboratory of Cornell University.

[2] Lintner, J. A. First Annual Report on the Injurious and other Insects of the State of New York. Albany, 1882, 281–288 p.

[3] Matausch, I. Observations on the Life History of Enchenopa binotata Say. Journ. N. Y. Ent. Soc., March, 1912, Vol. XX: No. 1, p. 58–67, pls. V and VI.

[4] Fitch, Asa. Fourth Annual Report of the Regents of the University of the State of New York on the State Cabinet of Natural History. 1851.

the eggs are laid, not in the bark of the slender twigs, but at the base of the buds and in the buds themselves. In oviposition the female rests on the bud with the head pointed towards the apex and inserts the ovipositor in the base of the bud, usually between two of the lower scales, especially when the winter eggs are being deposited. The ovipositor sometimes enters the twig just below the scales but in almost all cases the insect has some part of its body resting on the bud. Oviposition lasts from ten to twenty minutes after which the insect moves slightly around the twig or to a neighboring bud and repeats the process; three consecutive ovipositions by one female have been noted in the field. This process is most commonly observed during the latter part of August. The egg-slits are rather large, about 1.5 mm. long at the opening and 3 mm. long at the bottom of the slit, and since the buds at the time the eggs are laid, are not usually more than 6–8 mm. in diameter, and the twigs below the buds, which are occasionally infested, about 5–6 mm. in diameter, the egg-mass occupies a considerable part of the host. Two such slits are made, side by side, and about 2 mm. apart. They diverge at the bottom, however, the planes of the slits being at a considerable angle, so that the bottoms of the slits are some distance apart, often at opposite sides of the bud. In each of these punctures from three to six eggs are laid, the usual number apparently being five on each side. The eggs are about 1.5 mm. long and .3 mm. in greatest diameter, often slightly flattened, somewhat curved, more or less flask-shaped and of an opaque white color. The eggs are seldom covered with the frothy deposit so characteristic of this species on other hosts. At first I believed that it was never present, but I have occasionally succeeded in finding it. When present it is not white but a dirty yellow and much thinner and smoother than that which covers the eggs on the locust, on which host I have often seen the insects excrete the substance. I have never found this frothy mass on the buds but only on the twig at the base of the bud. Whether the epidermis of the butternut is or is not conducive to this method of egg protection would be a matter of conjecture.

The nymphs first appear locally about the first week in May. The earliest field record is May 3, 1912. There are five instars, each of which may be recognized by more or less distinct characters of the thorax and abdomen. The nymphs are covered with a white powdery coat which is almost woolly in the younger stages. On the butternut the nymphs retain this white covering throughout the entire five stages and the last nymphal skin is snowy white, particularly on the thorax and on the sides of the abdomen. The opposite is true of the nymphs on other hosts, which, as observed by Matausch (*ibid.*, p. 65), lose this powdery coating after the second molt. The development of the nymphs re-

quires approximately six weeks; a colony which had just emerged on May 10, 1913, was enclosed in netting and of these the first adults appeared on June 21.

The ecdysis consumes from ten to fifteen minutes, the epidermis first splitting on the top of the head, then down the dorsal line of the thorax and finally down the abdomen. The head is first released, appearing rather suddenly, the legs are withdrawn more slowly, and the abdomen gradually worked out of its old skin, leaving a very perfect exuvium. For the last molt the insect moves to the underside of a leaflet and fastens itself securely by the first two pairs of legs. The newly emerged adult is very soft-bodied and almost white, but the normal colors appear in about forty-five minutes.

The adults are first seen in large numbers about the first of July. There is no evidence to show that they winter over in the adult stage. They are usually found grouped about the petioles of the leaves, sometimes on the leaflets, rarely on the twigs and never on the trunk. Unlike most of the local forms of the family, they are often found high up on the trees, although generally preferring the sunny ends of the lower branches. They are very active and fly well, leaving the petiole with a quick "snap" and flying occasionally for several hundred feet. The adults are most numerous in this vicinity in late July and early August and at this time are very abundant. On August 9, 1912, over 200 individuals were collected from one tree in the course of a half hour's collecting and on July 22, 1914, 162 specimens were taken from the lower branches of another tree in a few minutes by three persons collecting. The insects on the butternut are much darker in color than the individuals on other hosts. The males and females are alike in color, both being of a very deep brown, almost black, and both sexes being darker than the males of the species usually appear. So noticeable is this, that when mounted in a cabinet with specimens of the same species collected on other hosts, the difference is at once remarked. It would be interesting to know whether the sap of the butternut on which the insects feed, has anything to do with this variation in color.

It is interesting to note that locally, at least, *Enchenopa binotata* is not attended by ants, and there seems to be no record of such attendence in literature. This is rather remarkable in view of the fact that most of our Membracidæ, particularly in the nymphal stages, are so attended. The nymphs of this species show the same extended anal tube as the nymphs of those species which excrete the fluid which attracts the ants, and they appear in numbers sufficiently large as to be easily discovered by the latter if there was any occasion for this mutual relationship. It should be noted in this connection, however, that

Baer has described[1] a species of the same genus, *Enchenopa ferruginea* Walk., as being attended by ants, and he has observed this species giving off the so-called "honey-dew."

Enchenopa binotata appears commonly in this vicinity on locust, bitter-sweet, wild grape, sycamore, hickory and willow, as well as on the butternut but on none of the former hosts does it show the dark color, the absence of the frothy deposits or the habit of laying eggs in the buds.

This species appears to be of decided economic importance, since it has been reported on a wide variety of host plants and has been known to seriously injure many of them. In the case of the butternut the buds are often entirely destroyed and adventitious growth is found starting from beside the punctured buds which have failed to develop.

I am indebted to Miss Leona Smith for a very fine series of both nymphs and adults of this insect, all collected from the butternut.

EFFECT OF LOW TEMPERATURE ON THE OYSTER-SHELL SCALE

(*Lepidosaphes ulmi* Linn.)

By R. L. Webster

The writer has already noted in general the fact that certain low temperatures of January, 1912, killed the eggs of the oyster-shell scale in many localities in Iowa.[2] Late in 1912, nearly a year after the extreme cold weather, some further data were obtained on the subject. Circular letters requesting samples of the scale were sent out from the office of the State Entomologist to correspondents that had previously sent in specimens. Again in December, 1914, letters requesting additional scale-infested twigs were sent out. All these samples were examined by the writer for sound eggs.

The results in the two years were very different. In the first case, scarcely any scales containing sound eggs were found. In the second, however, most of the samples contained scales with sound eggs. The scale had been practically wiped out in 1912, but in January, 1915, had regained most of the lost ground.

An account of the examination of the samples follows. The notes used are from the files of the entomological section of the Iowa Agricultural Experiment station at Ames.

In order to understand the significance of these observations a brief outline of the life history of the oyster-shell scale is necessary. During

[1] Baer, G. A. Note sur un Membracide myrmecophile. Ann. Soc. ent. France, 1903, LXXII: Bull. 306.

[2] Journ. Econ. Ent., Vol. 5, p. 470, 1912.

the winter the insect exists in the egg stage, under the scales on the bark of apple and other trees. Near Ames the eggs hatch from about the 10th of May to the 1st of June, depending on the season. The tiny crawling young soon settle down on the bark of the infested tree and proceed to secrete their scaly covering. This is finished in July and late in that month the eggs of the scale insect begin to appear under the mature female scales. There is a single generation, and from the first of August until about the middle of May, a period of nearly ten months, the eggs only are present beneath the scales.

Most of the reports of injury by this insect are from the northern half of the state, as shown in Figure 14. Normally, at least in the last ten years, orchards in this part of the state have been especially susceptible to the scale. Although it occurs in southern Iowa, it is seldom injurious there.

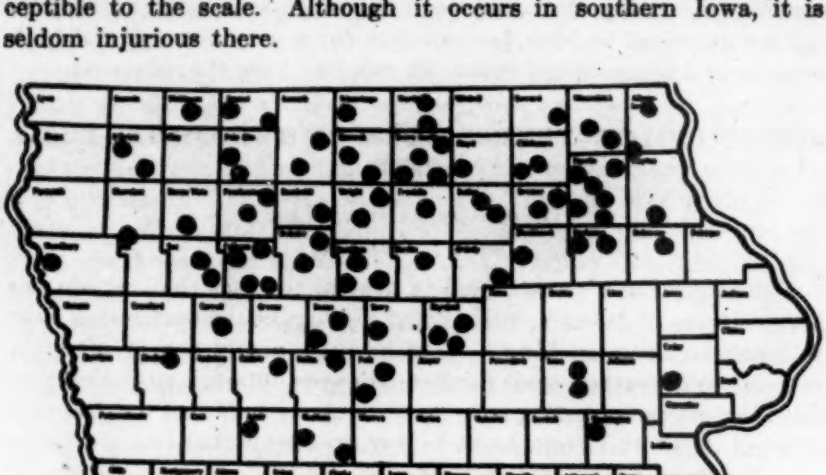


Figure 14.—Localities in Iowa where the oyster-shell scale has been reported as causing damage.

Several hundred scales were examined from each sending, enough to form an accurate idea of the condition of the eggs. As a rule a number of apple twigs were sent, and scales from every twig were examined.

Condition in Winter of 1912–1913

Fifty-four samples of scale were received in response to the first circular letter. These represented 45 localities. Sound eggs were common in only 6 samples. In 6 others there were traces of sound

eggs, but these were so rare that no counts were made. All the remaining samples contained no sound eggs, showing that even at this time, nearly a year after the extreme low temperature, the insect had not begun to regain the lost ground.

Figure 15 shows the condition of the scale in the winter of 1912–1913, together with isotherms of minimum temperatures for January, 1912. All the temperature records are taken from the Iowa Climatological Service of the Weather Bureau, Report for January, 1912.

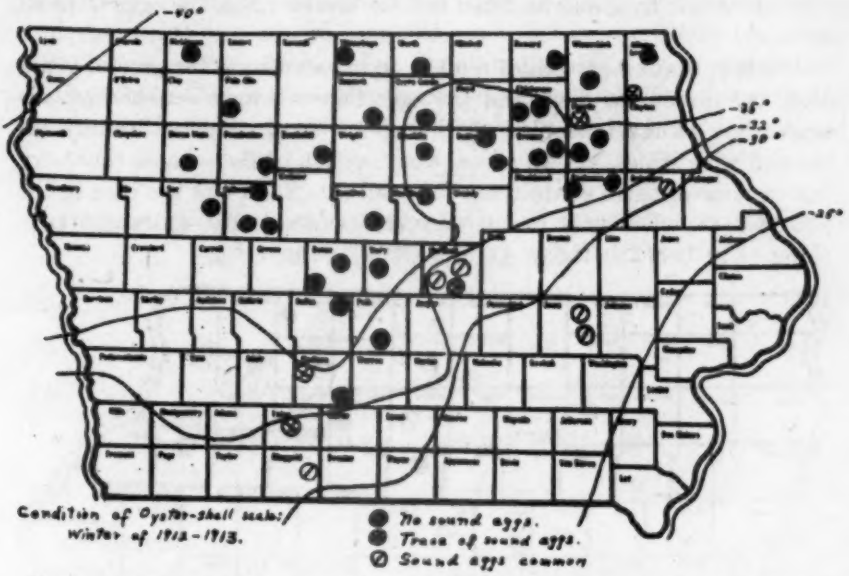


Figure 15—Localities in Iowa where the oyster-shell scale was killed in January, 1912, where it survived, with isotherms of minimum temperatures for January, 1912.

All the localities where no sound eggs were present are included north of the –32° isotherm. That is, a temperature of –32° F. evidently was too cold for the eggs to survive. That they did not survive this temperature is shown by the fact that the scale did not breed in the area north of the –32° isotherm, in the summer of 1912, and so no live eggs were found beneath the scales that fall. Many scales remained on the trees, but there was nothing living beneath them.

On the other hand, in Marshall county, where the minimum temperature was –31°, many scales contained live eggs in the fall of 1912. From the data at hand, it would appear that eggs might safely withstand a temperature of –31°, and yet succumb at –32°. However, since the temperature records and samples of scale frequently were taken in slightly different localities, there is some opportunity for

error. Accurate experiments are necessary to establish the precise temperature at which the eggs are killed.

In the previous article I mentioned that a very few young insects hatched out at Ames in the spring of 1912. However, this was observed on a single tree, and on only one branch of that tree, a branch close to the ground on the southeast portion of the tree. Most probably this limb had been protected by snow during the extreme weather, so that it was not subjected to quite so severe cold as the rest of the tree. On the rest of this tree, and on other trees in the orchard, the eggs were all killed.

The fact that empty scales remain on infested trees for several years after the insect has died, and the eggs beneath have hatched out, is misleading to most people. A branch of wood may be literally incrusted with scales, yet an actual examination of these show that very few or none of them contain anything alive. Such was the case in the fall of 1912, when only rarely were scales found that contained anything alive beneath them.

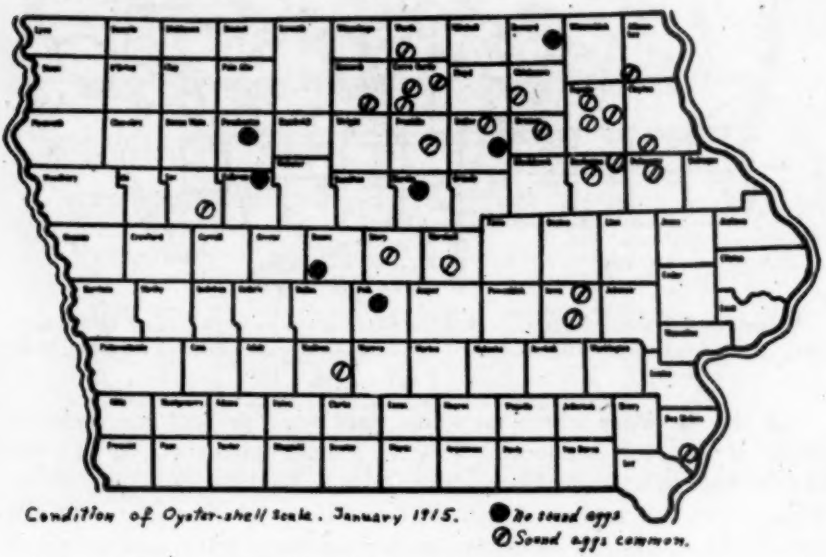


Figure 16—Condition of oyster-shell scale in January, 1915.

Condition in Winter of 1914–1915

Only 3 samples of the scale were received in response to the request of December, 1914. More replies than this were received, but no samples of scale were sent. For instance, in 9 cases the parties addressed could not find samples to send in, though previously they had

sent infested twigs. It appeared that the scale had been checked severely in those localities.

In 7 cases samples sent in contained no sound eggs beneath the scales. Here it was clear that the insect had not recovered from the check received in the winter of 1911–1912, since no indications of life were present 3 years later.

However, in 24 localities, sound eggs were present beneath the scales. This is in striking contrast to the previous report. In certain counties in northern Iowa where the insect had been apparently wiped out, according to scales examined 2 years before, were now (January, 1915) well infested with scales containing sound eggs in abundance. In 2 years the condition had returned, in these localities, to one similar to that immediately previous to the winter of 1911–1912.

CONFUSION OF RHOPALOSIPHUM HIPPOHAES KOCH,[1] AND MYZUS BRAGGII GILLETTE

By C. P. GILLETTE, *Ft. Collins, Colorado.*

Rhop. hippohæs Koch.

Rhop. hippohæs Koch.—Pflanzenlause, Aphiden, p. 28, 1854.
Phorodon galeopsidis Pass.—Aphidæ Italicæ, 1860.
Phorodon galeopsidis Kalt.—Buckton, Monograph British Aphididæ, V, I, p. 171, 1876.
Rhop. hippohæs Kalt.:—Schouteden, Catalogue des Aphides de Belgique, 1905, p. 235.
Myzus elæagni, del Guercio:—Davis, Annals Ent. Soc. of Am., V, 1, p. 251, 1908.
Phorodon galeopsidis Kalt.:—Davis, Jour. Econ. Ent., p. 325 and 331, 1911.

I believe the preceding bibliography and synonomy and the following brief discussion of the literature upon the above species will help to straighten a rather bad tangle in aphid literature.

Koch took his *Rhopalosiphum hippohæs* from the shrub *Hippohæ*, in the month of June. It happens that this plant serves as the over winter host for both the species under discussion and Koch, both in his descriptions and his figures, gives the alate form of *hippohæs* and the apterous form of *braggii*, or a closely allied species, which is not at all strange, as these two species are remarkably alike in coloration and general appearance.

Kaltenbach took his *Aphis galeopsidis* from species of *Lamium*, *Polygonum* and *Stachys* during September, which are the summer hosts. The apterous lice had capitate hairs and both apterous and

[1] This species probably belongs in the new genus *Capitophorus* Van der Goot. See Zur Systematic der Aphiden, p. 84, 1913.

alate forms had clavate cornicles and a strong tubercle on the inner surface of the second joint of the antenna.

Not having the papers of Walker and Passerini, I shall have to omit their comments, but Buckton has evidently made the same mistake as Koch in confusing the two species except that he has figured what seems to be the apterous form of *hippohæs* and the alate form of *braggii*, and mentions as food plants species of *Galeopsis*, *Lamium*, *Stachys*, and *Polygonum*, and states that the specimens figured were from *Polygonum persicaria* in September.

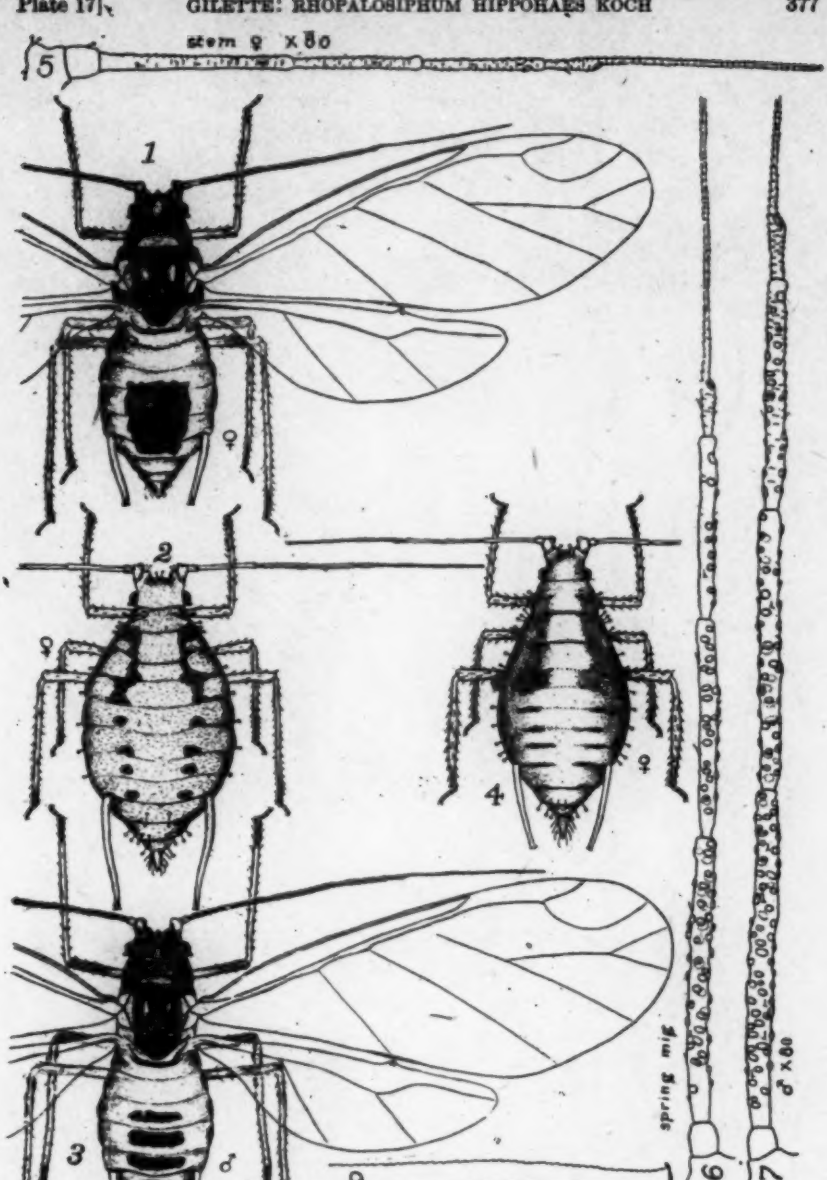
Schouteden evidently had the true sexual forms of *hippohæs*, both of which he described with clavate cornicles, the specimens figured being from *Hippohæs rhamnoides* and *Elæagnus* sp., but he does not mention the date.

Davis, in his paper in *Annals*, 1908, describes and figures the winged and wingless viviparous female, and the oviparous female, and refers to the original descriptions of *Myzus braggii* in *Canadian Entomologist*, January, 1908, for the characterization of the winged male and the winged and wingless viviparous females, but *braggii* always has cylindrical cornicles so that, once more, the two species were confused.

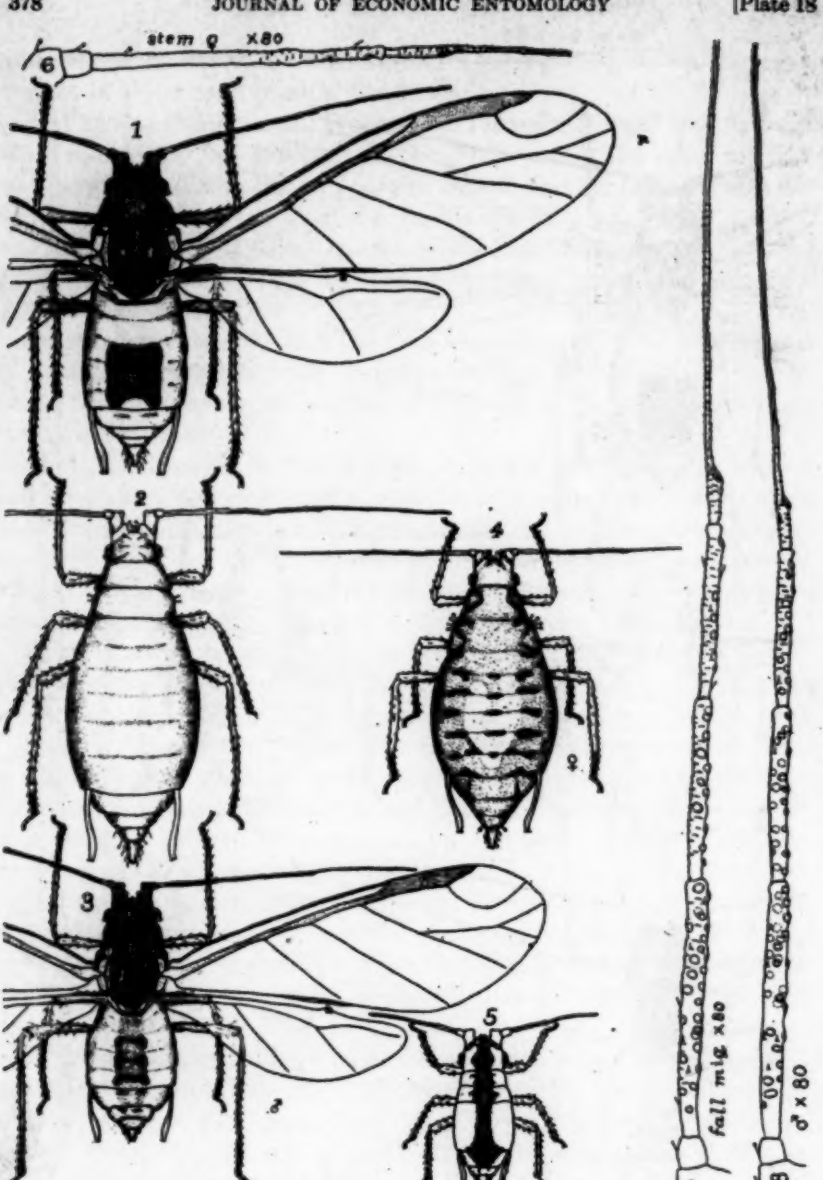
There is no doubt which species Davis had as he describes the clavate cornicles and gives a good figure. Professor Davis also took his specimens on *Elæagnus* in September.

Then, in his paper in JOURNAL OF ECONOMIC ENTOMOLOGY for 1911, p. 325 and plate 10, Mr. Davis has given descriptions and figures of *hippohæs* which seem to be identical with his descriptions of *elæagni* (*hippohæs*) in *Annals*, mentioned above. It seems that Davis either made a mistake in sending del Guercio a cylindrical, cornicled *braggii* (*hippohæs*) for determination, or else del Guercio made the mistake of overlooking the cylindrical cornicles in the specimens Davis sent. If, on the other hand, the *elæagni* described by del Guercio had clavate cornicles, it seems extremely probable that he was working with *hippohæs*.

At Fort Collins we find *braggii* common and often very abundant upon the Canada thistle (*Cirsium arvensæ*) during the latter part of summer and early fall every year, and it also occurs on artichoke, *Cynara*, *Scolymus;* the winter hosts are the Russian olive, *Hippohæs rhamnoides* and *Shepherdia arvensis*. *Rhop. hippohæs* we take upon *Polygonum* during the summer and upon Russian olive and *H. rhamnoides* during the fall, winter and spring. We have never found the form with clavate cornicles upon the Canada thistle; neither have we found the form with the cylindrical cornicles upon *Polygonum*, or *Persicaria*, but both forms occur upon the Russian olive (*Elæagnus*) and *Hippohæs*.



Myzus braggii, Gillette: 1. alate viviparous female; 2. apterous viviparous female; 3. alate male; 4. oviparous female; 5. antenna of stem female; 6. antenna of spring migrant; 7. antenna of male; 8. antenna of oviparous female; 9. cornicle of oviparous female; 10. hind tibia of oviparous female.
Figures 1-4 enlarged 20 diameters; all others 80 diameters.



Rhopalosiphum hippolaes: 1. alate; 2. apterous viviparous female; 3. alate male; 4. oviparous female; 5. young male; 6. antenna of stem female; 7. fall migrant; 8. apterous female; 9. oviparous female; 10. hind tibia of oviparous female; 11. cornicle of oviparous female. Lice all enlarged 20 diameters, and all other figures 80 diameters.

Drawings by Miss M. A. Palmer.

During the fall of 1913, *hippohæs* was traced from *Persicaria* to *Elæagnus* and *Hippohæs*, where the oviparous females were deposited, the winged males coming later. In the spring of 1914, branches of *Elæagnus* and *Hippohæs rhamnoides* having eggs of *Rhop. hippohæs* and *Myzus braggii* were taken to the insectary where they hatched and the second brood developed wings in both species. *Rhop. hippohæs* was placed upon *Persicaria* where the alate specimens immediately gave birth to young which remained on the plant. These passed through ten generations on this plant. *Myzus braggii* was placed upon the Canada thistle and was reared with equal success.

The figures on Plates I, and II, will indicate how distinct these two species are.

Another species of Rhopalosiphum, closely allied to *hippohæs* but more robust, with capitate hairs upon the dorsum of both the apterous and alate forms and with filament of antenna much shorter than in *hippohæs*, has been taken repeatedly upon *Elæagnus* and *Hippohæs* but the summer host has not been found. It is very well represented by Koch's Figure 37, except that the cornicles are clavate near the end as in *hippohæs*.

A DESTRUCTIVE PINE SAWFLY INTRODUCED FROM EUROPE.

Diprion (Lophyrus) simile Hartig

By W. E. Britton, *State Entomologist*,
New Haven, Conn.

On August 27, 1914, in company with my assistants, Messrs. I. W. Davis and M. P. Zappe, while inspecting a nursery in New Haven, a few scattered sawfly larvæ were noticed feeding upon the foliage of pine trees six to eight feet tall. This work was continued for the next few days and, in one part of the nursery, where several species of pines were planted for exhibition and sale, the larvæ were rather abundant, and the men spent an hour or more gathering all that could be found and the material was taken to the laboratory.

Supposing it to be a native and not uncommon species, and knowing that Dr. A. D. MacGillivray, who has prepared the portion concerning sawflies for the forthcoming Hymenoptera of Connecticut, was studying sawfly larvæ, some of this material was sent to him and the remainder placed in breeding cages in our insectary. Dr. MacGillivray did not recognize the species from the larvæ but thought that he might identify it if the adult stage could be obtained. On April 8, 1915, a male emerged from a cocoon in one of the cages, followed by others, and on April 15 a female appeared. Some of the males and females

were transferred to cages containing small potted white pine plants and eggs were soon obtained.

On April 21, I wrote about this to Dr. MacGillivray, who at once examined his cages and found some adults. He stated that he did not know the species but that it belonged to the genus *Diprion* formerly known as *Lophyrus*. The species are badly confused and he recommended that we send material to Mr. S. A. Rohwer, of Washington, D. C., who is at work on the group and has examined many of the types in the British Museum. Consequently some adults of both sexes, an inflated larva and a pupa case were submitted on May 6, to Mr. Rohwer who wrote as follows:

"I have determined this species, tentatively, as *Diprion simile* Hartig. The adults agree more closely with those in the collection under the name *pini* but the larvæ answer exactly the description of *simile*, and as these two species are very closely allied and easily confused in the adults I have made the determination from the larvæ rather than from the adults.

"This species is one of the most injurious sawflies on European conifers and has been associated in practically all of the depredations caused by *pini*, and is recorded in the literature in a number of cases under the name of *pini*. You are no doubt familiar with the economic importance of *Diprion pini* in Europe. It is highly important that immediate measures be taken to combat this injurious insect as it has a large number of host trees and would no doubt adapt itself readily to the conditions in America, where, if it were thoroughly established without its parasites, it would do a great deal of damage."

The appearance of this insect in all its stages is shown on plate 19 and briefly may be described as follows:

Egg.—The eggs are laid end to end in slits made along one of the ridges at the edge of the needle. The eggs are pale blue in color, smooth and slightly shining. The sides are parallel with the ends rounded. Length, 1.25 mm., thickness, .33 mm. In the material examined the newly laid eggs were slightly separated in the slits. The eggs before hatching increase in size, becoming crowded in the slits so that the ends are flattened like peas in a pod.

Larva.—Length, 25 mm. (1 inch) to 28 mm. (1 1/8 inches). Thickness, 4 mm. (3/32 inch). Head black, body greenish yellow with a mid-dorsal double stripe of brown extending the entire length. On either side of the dorsal stripe is a yellow stripe broken with transverse markings of brown. The remainder of sides dark brown with many irregular yellow or whitish spots. Ventral surface pale yellow or white. Pro-legs yellow with a transverse black mark at base, true legs marked with black and yellow.

Cocoon.—9 mm. long (about 3/8 inch), thickness about 5 mm., oval in shape, tough leathery and fairly smooth. Color, sepia.

Male.—Wing-spread, 14 mm. (9/16 inch). Length, 7 mm. Large pectinate antennæ. Head and pronotum coarsely punctured. Head, antennæ and body,

black. Cerci and tip of the last abdominal segment, orange. Legs yellow, with the trochanters and basal two-thirds of the femora, brownish black.

FEMALE.—Wing-spread, 20 mm. (little over 3/4 inch). Length, 8 mm. (5/16 inch). Robust, head and antennæ black. Thorax coarsely punctured, yellow with a large shield-shaped black spot on mesothorax, extending from the anterior margin and covering about two-thirds of the space between the parapsidal grooves. On either side are a pair of L-shaped black marks which approach each other posteriorly. Posterior margin of the mesothorax, postscutellum and prosternum, black. Abdomen yellow with dorsal surface of 3d, 4th, 5th, 6th, and the anterior portion of 7th segment, black. Legs yellow with the outer surface of hind femora, the apex of the middle and hind tarsi, dark.

Lophyrus similis Hartig is mentioned by Kaltenbach[1] as occurring with *L. pini*, the larvæ appearing in June and the adults from July to September. Judeich-Nitsche[2] also include this species with *L. pini*, *L. rufus* and *L. pallidus* and state that the full-grown larvæ will each devour from six to twelve needles per day, preferring the old needles.

More recently, however, Dr. L. Reh[3] places *simile* as a synonym of *pini*, and states that it is one of the most important species of the genus, feeding upon all kinds of conifers and having two generations each year. The young larvæ feed upon the edges of the needles leaving only the midrib but later they devour the entire needles. The summer brood makes cocoons on the branches of the tree, and the fall generation makes cocoons on the rubbish underneath it.

For several years *Lophyrus pini* has seriously damaged the pine forests of Southwestern Russia,[4] especially the young trees. This species was particularly destructive in France[5] in 1906, and it has also done damage in Prussia and in Sweden. In England it is said to injure Scotch Fir[6] as well as pine.[7]

In the Connecticut nursery the larvæ were found feeding upon the white pine, *Pinus strobus;* the Austrian pine, *P. laricio* var. *austriaca*, *P. flexilis* and *P. densiflora*. These trees were sprayed with lead arsenate in September.

In Europe raking up and destroying the leaves and other rubbish under the trees in fall is recommended to destroy the cocoons.

Spraying the foliage with arsenate of lead will also prove effective.

It is hoped that entomologists will be on the watch for this insect

[1] Die Pflanzenfeinde, p. 700, 1874.

[2] Forstinsektenkunde, p. 635, 1895.

[3] Handbuch der Pflanzenkrankheiten, Die Tierischen Feinde, Dritter Band, p. 598, 1913.

[4] Review of Applied Entomology, Vol. I, pp. 395 and 493, 1913.

[5] A. Barbey, Traité D'Entomologie Forestière, p. 269, 1913.

[6] W. E. Collinge, A Manual of Injurious Insects, p. 217, 1912.

[7] E. A. Ormerod, Manual of Injurious Insects and Methods of Prevention, p. 250, 1890.

which has been imported into the United States and apparently become established here. Its method of introduction is, of course, unknown but it is probable that a few cocoons on the branches or in the packing material of pines from Europe were overlooked by the inspector.

Mr. Rohwer has kindly furnished the following references, which apply only to *D. simile:*

HARTIG, T.—1834. Forstliches Convers.—Lexicon 2. Aufl. p. 987. (Original account.)

HARTIG, T.—1860. Die Familien der Blattwespen und Holzwespen, p. 160, pl. III, fig. 9 (Original description and a short account of life history and presence around Berlin and Stettin.)

BAER, W. —1906. *Lophyrus similis* Hart.—Naturwissenschaftliche Zeitschrift für Land- und Forstwissenschaft. vol. 4, H. 2, p. 84–92, 10 fig. (Contains many notes but publication is not at present minute available, so cannot be summarized.)

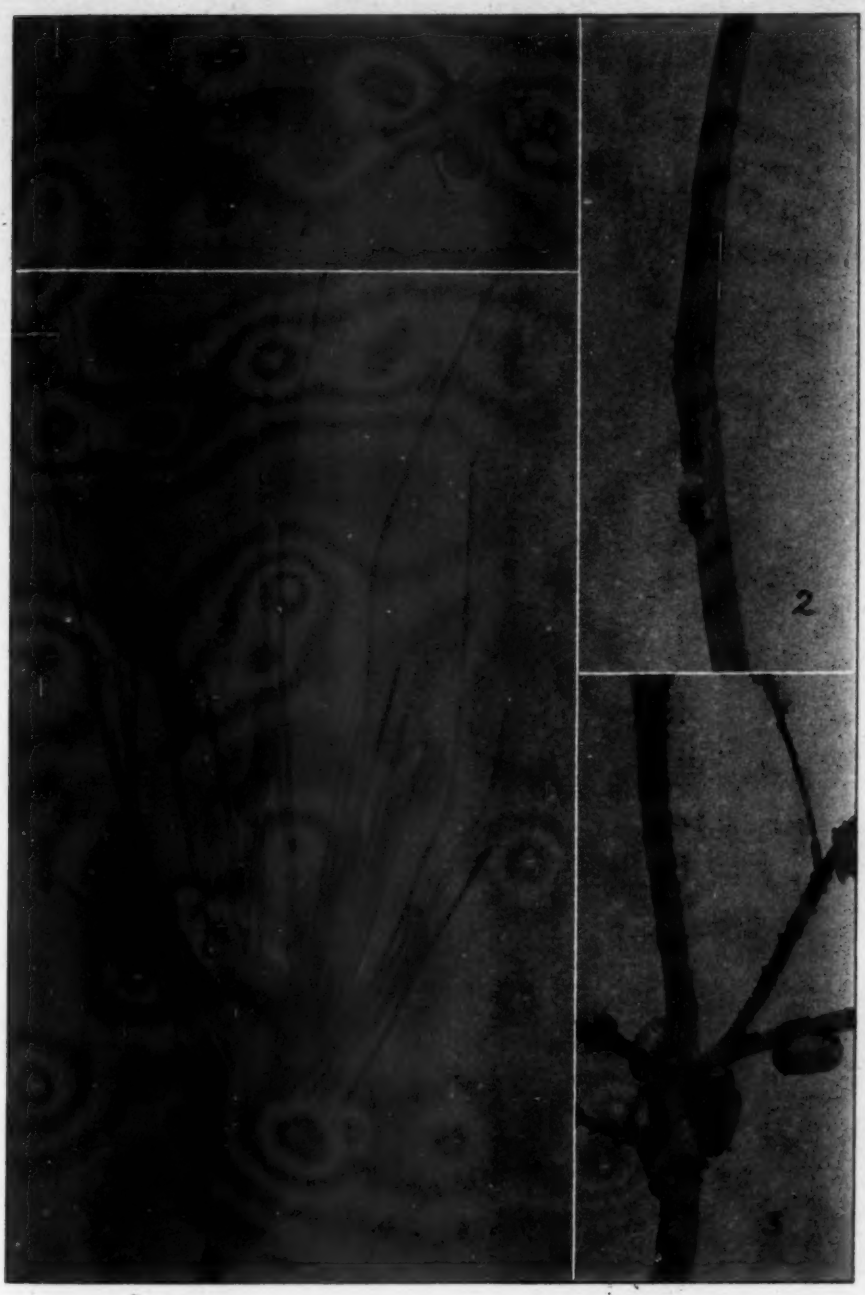
FORSIUS, R.—1911. Medd. Soc. Fauna Flora Fennica, vol. 13, p. 183. (Presence in Finland in 1910.)

Reviews.

Key to the Families of North American Insects, an Introduction to the Classification of Insects, by CHARLES T. BRUES and A. L. MELANDER. Published by the Authors, Boston, Mass., and Pullman, Wash., 1915, pp. i–viii, 1–140.

The past twenty years have witnessed a wide departure from the primary seven principal orders of the early entomologists, a process which has advanced by gradual stages and appears to have reached its climax in this tabulation. Most entomologists recognize the necessity of more exactly defining the larger groups and though by no means all will agree with the system adopted in this work, they must admit that it presents within a very brief compass, considering the complexities of the subject, an excellent analytical key. A most praiseworthy feature, not always seen in technical works, is the evident attempt to correlate the system with earlier ones and particularly to establish a definite relation with economic forms. There are, in addition to the keys, a conspectus of the higher groups of insects, five classes being recognized, brief statements of the ordinal characters, a series of 18 line plates illustrating typical forms or structures, a glossary and indices of both scientific and common names. This laboratory manual will be exceedingly helpful to all entomologists and we hope it may prove a potent factor in establishing a more satisfactory arrangement of the larger groups of insects.

Erratum. Page 269, line 2 for *Carpophilus latinasus* read *Caulophilus latinasus.*



Diprion simile: Hartig. 1. Adults, twice natural size; 2. Eggs in pine needle, about 4 times enlarged; 3. Cocoons, natural size; 4. Larvæ feeding on pine, natural size.

JOURNAL OF ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

JUNE, 1915

The editors will thankfully receive news items and other matter likely to be of interest to subscribers. Papers will be published, as far as possible, in the order of reception. All extended contributions, at least, should be in the hands of the editor the first of the month preceding publication. Contributors are requested to supply electrotypes for the larger illustrations so far as possible. Photoengravings may be obtained by authors at cost. The receipt of all papers will be acknowledged.—Eds.

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The summer meeting in California deserves the hearty support of every active entomologist. It will afford one of the best opportunities of getting into closer touch with a large body of aggressive investigators, who, partly on account of the peculiarities of their problems and also because of distance, are somewhat separated from the eastern students, though we are all in a land where there is no East or West, no North or South, scientifically speaking. The western men are of themselves capable of making this gathering a notable one in the annals of science. The eastern students of insect life have a duty, though extremely pleasant, in relation to this meeting. It is earnestly hoped that all sections of the country may be adequately represented at the coming meeting.

Substantial progress, it will be noted by referring to the Current Notes, has been made in the preparation of the Index of Economic Entomology, the continuation of the well known and frequently used Bibliography of American Economic Entomology in what is hoped will prove a more useful and convenient form. Publications of this kind are frequently consulted with little thought of the labor, often thankless, involved in their preparation. The work now being compiled covers a decade and is going to prove immensely helpful to every progressive worker. The compiler should have every possible assistance and it is very probable that a few words of appreciation for the man who has the patience to carry such a work through to completion would not come amiss. There must be many entomologists who have a personal as well as a professional interest in the publication of any such compilation.

Current Notes

Conducted By The Associate Editor

W. V. King, Bureau of Entomology, received the degree of doctor of philosophy from Tulane University, in January.

Mr. Frank R. Cole has been appointed scientific assistant, Bureau of Entomology, to work temporarily at Pasadena, Cal., and vicinity.

Mr. Thomas H. Jones of the Bureau of Entomology is stationed at Baton Rouge, La., and is investigating truck crop insects.

Mr. R. J. Fiske, Bureau of Entomology, is now stationed at Roswell, N. H., where he is engaged on codling moth investigations.

Mr. H. P. Wood, Bureau of Entomology, now located at Dallas, Texas, was married to Miss Ester Danielson of Hopedale, Mass., April 3.

The Department of Entomology of the Texas Agricultural College, has just completed a greenhouse, for use as an insectary, at a cost of $1,200.

Mr. C. E. Smith has been engaged by the Bureau of Entomology to assist Mr. Thomas H. Jones in work on truck crop insects at Baton Rouge, La., and vicinity.

Mr. E. R. Speyer has taken up a temporary appointment under the Ceylon government for the purpose of investigating the shothole borer of tea (*Xyleborus fornicatus*).

Mr. Richard Lydekker, F. R. S., the well-known English zoologist, died April 16, aged 65 years.

J. L. Webb, Bureau of Entomology, left Washington on April 25th for Tallulah, La., where he will be attached to the boll-weevil laboratory.

Mr. F. W. Dry, a Carnegie scholar, is on a trip with Professor Webster, visiting the eastern field stations of the section of Cereal and Forage Crop insects.

According to *Science*, Professor M. A. Lameere, University of Brussells, has been nominated as an honorary member of the Societé Entomologique de France, in place of the late M. J. Perez.

T. C. Barber, recently of the experiment station at Tucuman, Argentina, has been engaged as an agent of the Bureau of Entomology, and is attached to the Tallulah laboratory.

Mr. R. S. Clifton, executive assistant of the Bureau of Entomology, is now stationed at the headquarters of the gypsy and brown-tail moth investigations, 43 Tremont St., Boston, Mass.

Dr. Henry H. P. Severin has again accepted a temporary position for the summer at the Maine Agricultural Experiment Station to test the poisoned bait spray to control the currant or gooseberry fruit-fly and the apple maggot.

Messrs. R. W. Wells, M. J. Stanley, and G. H. Cowan have been appointed to service in the Bureau of Entomology, in connection with the spotted-fever tick work in Montana.

Governor Ferguson of Texas, on March 22, approved an emergency appropriation of $3,000 for eradication of foul brood in that state. The work will be in charge of State Entomologist Wilmon Newell.

Mr. Arthur J. Ackerman, Bureau of Entomology, spent the winter in Washington and in March started on a short trip through the southern states investigating nursery insects. As last year, he is located at West Chester, Pa.

A. H. Jennings, Bureau of Entomology, who has been engaged for some time in the study of the possible transmission of pellagra by insects, will be detailed to the investigation of malarial mosquitoes. He is now located at Mound, La.

B. R. Coad, Bureau of Entomology, has been placed in charge of the boll-weevil laboratory at Tallulah, La. G. D. Smith, formerly of this station, has been located at Thomasville, Ga., where he will conduct studies of a number of cotton pests.

Mr. W. F. Fiske is now engaged in an investigation of the tsetse flies (*Glossina* spp.) for the Tropical Disease Commission and is stationed in the vicinity of Lake Victoria Nyanza, where he plans to remain for the next fourteen months.

Second Lieutenant Duncan H. Gotch, Worcestershire Regiment, entomological assistant in the Imperial Bureau of Entomology, was killed in action at Neuve Chapelle on March 11.

Professor C. L. Metcalf of Ohio State University will spend the summer months, beginning June 15, at the Agricultural Experiment Station, Orono, Maine. He will be engaged in a systematic and economic study of the Syrphidæ.

Mr. E. P. Taylor has resigned as field horticulturist, Extension Department of the University of Idaho, Boise, Idaho, and accepted the position of horticulturist, Utah Fruit Growers Association, Box 1878, Salt Lake City, Utah.

G. A. Runner, Bureau of Entomology, spent several days during April in the laboratories of the General Electric Co., Schenectady, N. Y., conducting experiments in the destruction of the cigarette beetle (*Chalcodermus aeneus*).

Mr. Carlton C. Gowdy, government entomologist in British East Africa, was given a ten months' leave of absence and spent the winter months in advanced work in entomology at the Massachusetts Agricultural College, of which he is a graduate in the class of 1908.

Mr. Neale F. Howard, a graduate of the Agricultural College, University of Wisconsin, will work with the Bureau of Entomology on the pea aphis, root maggots, and other insects affecting truck crops, with headquarters at Green Bay, Wis., in cooperation with the University of Wisconsin.

U. C. Loftin, Bureau of Entomology, is now in Cuba where he will be engaged for several months in the study and collection of parasites of sugar-cane insects and the investigation of the relation between certain systems of culture and the sugar-cane borer.

Entomological News records the death of the following European entomologists: Ferdinand Kowarz, the well-known dipterist at Franzensbad, Bohemia, September 14, 1914; Dr. F. Trybom, of Sweden, February 15, 1915; Doctors Walter Stendell, Otto Kirchhoffer, W. Haas and F. Vogel who have been killed in the war.

Mr. O. K. Courtney, a graduate of the Texas Agricultural and Mechanical College, has been appointed to the position of assistant entomologist in the Department of

Entomology at that institution, succeeding Mr. Walter W. Marshall who has taken up graduate work at the Ohio State University.

The General Assembly of Connecticut adjourned on May 18, after appropriating $25,000 for the next two years for suppressing the gypsy and brown-tail moths. Of this amount $4,000 is immediately available for summer work. Twenty towns are now known to be infested with the gypsy moth and 72 with the brown-tail moth.

August Busck, Bureau of Entomology, left Washington early in May to spend six months in the Hawaiian Islands in the study of *Gelechia gossypiella*. Special information regarding the habits of this species are required in connection with the proposed action to prevent the establishment of the species in the United States.

Professor Henry E. Van Deman, first professor of horticulture in Kansas State University, and first head of the Division of Pomology, United States Department of Agriculture, died at his home in Washington, D. C., April 28. Since 1893 Professor Van Deman has been engaged in work of an editorial and advisory nature.

According to *Science*, Dr. Raymond C. Osburn, assistant professor of zoölogy in Barnard College of Columbia University, has resigned to accept the professorship of biology in the new Connecticut College for women at New London. It is understood that the college will be ready for work at the beginning of the next college year.

The following have been elected to the fellowships in entomology at the University of Illinois: Alvah Peterson, Knox College; Philip Garman, Kentucky Agricultural College. The following have been elected to scholarships; Edwin K. Parker, Massachusetts Agricultural College; L. B. Ripley, Trinity College, and J. L. King, Ohio State University.

The field laboratory of the Bureau of Entomology in Maine has been discontinued. Mr. F. L. Simanton, formerly in charge, has been transferred to the laboratory at Benton Harbor, Mich., where he will undertake investigations in connection with orchard insecticides and spraying machinery. He will be assisted by Mr. H. G. Ingerson.

Mr. W. M. Davidson, Bureau of Entomology, has returned to his headquarters, Walnut Creek, Cal., where he will continue his investigations in connection with the grape Phylloxera. During his stay in Washington the report on the biology of this insect was about completed, and another season's observations will complete the subject in a satisfactory manner.

Mr. Irving R. Crawford has been appointed temporary field assistant, Bureau of Entomology, and will proceed to San Diego, Cal., to collect parasites of *Hemileuca oliviæ* in northeastern New Mexico. The force engaged upon this investigation will consist of Mr. D. J. Caffrey, in charge; Messrs. Crawford and J. R. Sandige, temporary assistants; and a permanent appointee not yet selected.

F. C. Bishopp, Bureau of Entomology, Box 208, Dallas, Texas, has undertaken the taxonomic study of fleas. He has probably one of the largest collections in the United States at the Dallas laboratory but desires to obtain additional specimens from all parts of the country. It will assist greatly in his studies if material of this kind is sent directly to him.

Mr. P. H. Timberlake, Bureau of Entomology, who has been spending the winter at the Brownsville, Tex., laboratory, engaged particularly on the hymenopterous parasites of lady beetles, will return to Salt Lake about the middle of April, and on his

return Mr. L. P. Rockwood will be transferred temporarily to Forest Grove, Ore., to assist in the clover-insect investigations being carried on at and from that laboratory.

A card index to all illustrations used in the Bureau of Entomology and the former Division of Entomology, is maintained by the Bureau at Washington. It also includes the reports of the U. S. Entomological Commission and the later entomological papers of the U. S. Department of Agriculture. A general card index of all entomological publications issued by the U. S. Department of Agriculture is now being prepared.

A new project relating to the control of the house-fly and other insects in establishments operating under the meat inspection act has been approved by the Secretary. This is a joint investigation between the Bureau of Entomology and the Bureau of Animal Industry. The headquarters for the work will be at the Dallas laboratory and F. C. Bishopp will be in direct charge. A conference was held at Washington early in May at which the detailed plans for the investigation were discussed.

Mr. Carrington B. Williams, Carnegie scholar, took a trip to the West Indies in March and returned to Washington about April 8, with a very large collection of Thysanoptera made on the trip. On his return he worked night and day with Mr. J. D. Hood, of the U. S. Biological Survey, describing the new species for a joint paper soon to be published. He visited Barbados, Trinidad, and Porto Rico and saw some tropical economic entomology. He sailed for England on April 17.

Mr. E. H. Siegler, Bureau of Entomology, formerly in charge of the laboratory at Benton Harbor, Mich., in connection with the project of insecticide investigations, has been placed in immediate charge of the laboratory at Grand Junction, Colo., where, in coöperation with the Colorado Agricultural Experiment Station, he will undertake a thoroughgoing investigation of the codling moth in the Grand Valley. He will be assisted by Mr. E. R. Van Leeuwen.

A hearing before the Federal Horticultural Board was held in Washington, D. C., on May 6, in regard to extending the quarantine lines to include additional territory now infested by the gypsy and brown-tail moths. Messrs. A. F. Burgess, L. H. Worthley and D. M. Rogers of the Bureau of Entomology located at Boston, Mass., Professor W. C. O'Kane of New Hampshire, Irving W. Davis of Connecticut and Harry B. Weiss of New Jersey were among those in attendance.

The index of economic entomology, covering the literature since 1905, is now fairly under way. Two typists are engaged in assisting Mr. Nathan Banks in the preparation of the manuscript, and a third will soon be employed. More than one-half of the experiment station literature has been indexed, and work on the publications of the Bureau of Entomology is nearing completion. It is estimated that there will be at least 25,000 entries.

W. D. Hunter and G. B. Sudworth, of the Federal Horticultural Board, had a conference at Pittsburgh, Pa., on April 14, with the designers of a machine which may be adapted for the fumigation of bales of cotton. On April 20, a conference was held with the department regarding the proposed action of the Federal Horticultural Board, regarding the fumigation of all foreign cotton received in this country to destroy the immature stages of *Gelechia gossypiella*. Representatives of cotton mills from all parts of the country were present.

In conjunction with the Southern Conference for Education and Industry, held at Chattanooga, Tenn., April 27-30, there was a conference of southern beekeepers. The meeting on the first day was devoted to a discussion of beekeeping for teachers and others interested in the development of beekeeping in the South. The Tennessee State Beekeepers' Association called a special meeting in connection with this con-

ference on April 28–29. Dr. E. F. Phillips was chairman of the beekeepers' conference.

Mr. E. R. Sasscer, chief inspector of the Federal Horticultural Board, reports as a result of his inspection of the Introduction Garden at Miami, Fla., the finding of a new and dangerous scale insect infesting mangoes, namely, *Lecanium* (*Coccus*) *mangiferæ*. Incidentally he saw something of Mr. Yothers' work in Florida and reports as an eye witness some remarkable demonstration results from spraying, in which the fruit output was enormously increased and the quality much improved as a result of the treatment.

A considerable collection of books and magazines has been amassed by the State Entomologist and Director of the Illinois State Laboratory of Natural History, Professor Stephen A. Forbes, by purchase and exchange during the past twenty or more years. This collection has been supplemented in recent years by extensive purchases by the Library of the University of Illinois. There has been spent during the past biennium alone over three thousand dollars in the purchase of books on entomology and nearly six thousand dollars for zoological publications, many of which contain articles of great interest to the entomologist.

Messrs. H. G. Champion, of the University of Oxford and the Indian Imperial Forest Service, and T. E. Snyder of the Bureau of Entomology, spent some ten days during January touring lumber mills in the high mountains of West Virginia in the study of the industry and the insects involved. While visiting the Union tannery at Davis, W. Va., they were informed by the manager that, following recommendations to prevent injury by the tanbark borer (*Dinoderus substriatus* Payk.), they used all hemlock tanbark before it was four years old. Dr. A. D. Hopkins visited this tannery in 1901 and found that out of a total of 20,000 cords of bark about 10,000 were badly damaged by this beetle. On close investigation he found the damage was practically confined to bark that was from two to seven years old, and no appreciable damage was done in bark less than three years old. Accordingly, he recommended that, in order to avoid this loss, older bark be used first, and that no bark be kept for a longer period than three years. Thus, by following the suggestion then made, enormous loss has been prevented in this tannery alone.

The Mediterranean fruit-fly force at Honolulu now includes, in addition to the leaders, Dr. Back and Mr. Pemberton, also Messrs. Willard, Banks, and Maxwell, Ah Fook, a Chinaman, and Muto, the Jap. Aside from Muto, these men are all connected with the inspection service. The present arrangement puts Mr. Willard in general charge of this service under Dr. Back. Mr. Willard is a graduate of the Massachusetts Agricultural College, who came to the islands as instructor in agriculture and farm superintendent at the Mills Institute, Honolulu, and is reported by Dr. Back as being a very useful and serviceable assistant. Dr. Back, with Mr. Pemberton, will be engaged during the next three months in an investigation of the fruit-fly as affecting coffee, and other coffee insects of the Cona district, Island of Hawaii. This is the great coffee district of Hawaii. The pulp of the coffee berry is a favorite food of the Mediterranean fruit-fly and frequently as many as a dozen maggots of this fly can be taken from a single coffee berry which is no larger than a medium-sized cherry. Of vast interest to the coffee industry and to the fruit-fly control on the island is the fact reported by Dr. Back, that one of the parasites recently introduced on the island through the agency of the Territorial board of agriculture is already parasitizing the maggots in coffee berries to an average of upward of 50 per cent, in some instances reaching as high a percentage as 96. The parasite in question is *Opius humilis*. This seems to be another one of the many successful parasite introductions which have been carried out on these islands.

Mailed June 30, 1915.